IItems to be Considered if Appeal is Heard

I. **Violations -** To determine if the 10 violations are valid, please review all 28 MVP workbooks. Each workbook is linked below:

Math 1 Workbooks

Math 2 Workbooks

Math 3 Workbooks

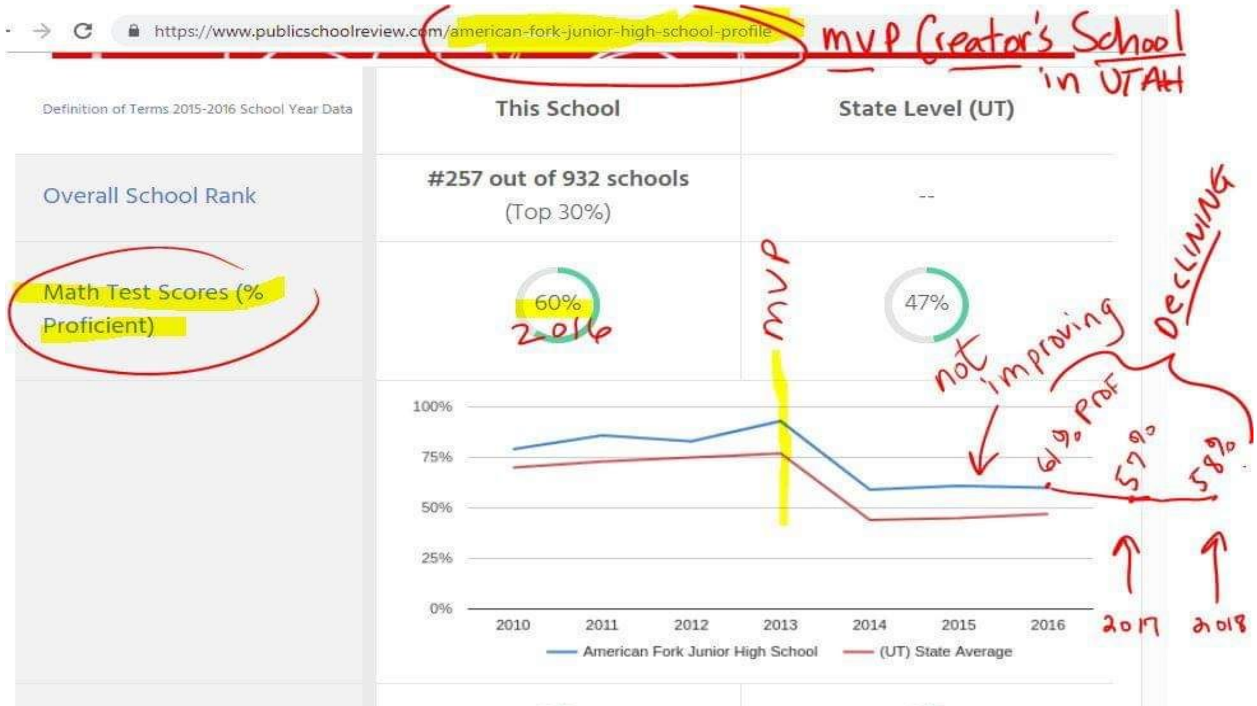
II. **Data Showing MVP causes declining math proficiency:**

1. Alpine, UT - Math proficiency scores declined significantly at the school where the creator of MVP teaches. The primary creator of MVP, Travis Lemon, teaches math at American Fork Junior High (AFJr) in Alpine, UT. AFJr feeds into American Fork High School (AFH) which does NOT use MVP. It is alarming that the high school in Lemon's hometown does not use his MVP curriculum. The math scores at AFJr where Lemon teaches have DECLINED.

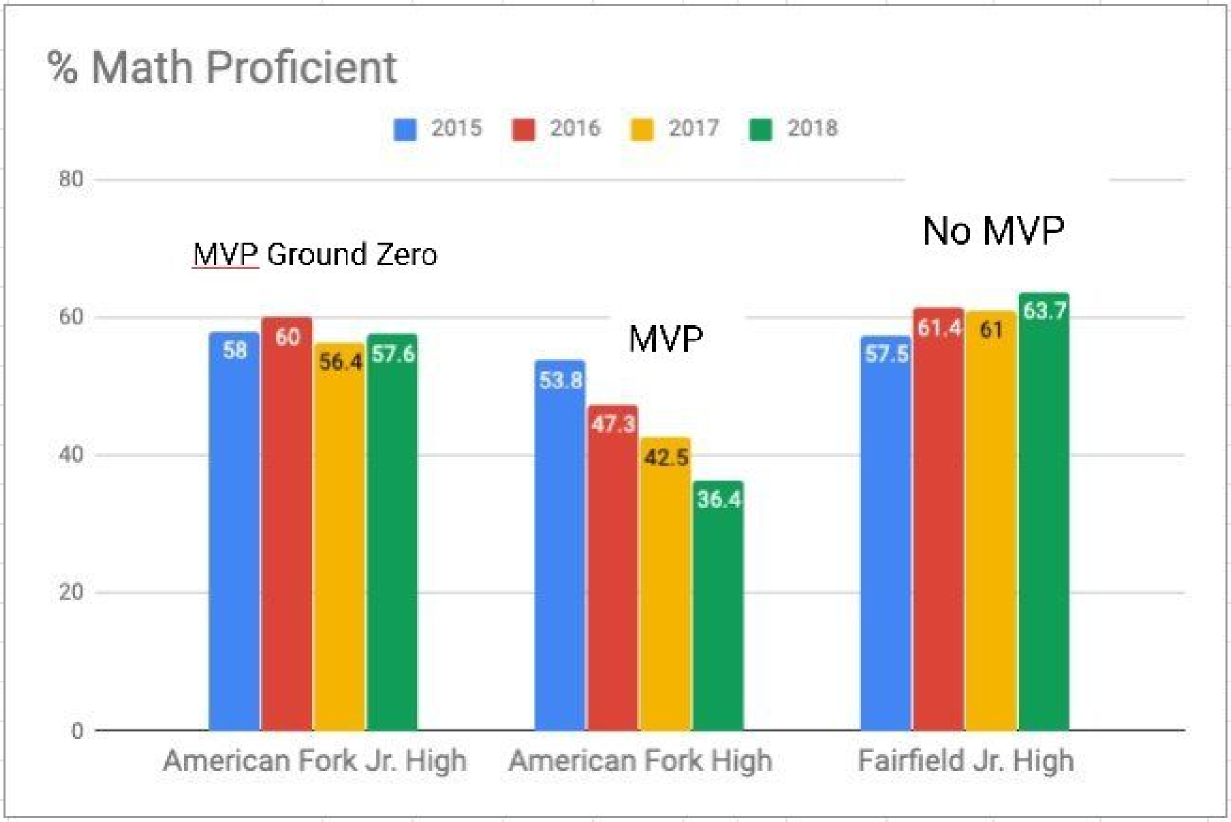
   The charts below (sources: publicschoolreview.com and utahschoolgrades.schools.utah.gov and wakemvp.com) show that math scores at AFJr went from above 80% math proficiency before 2013 (pre-MVP), down to 60% math proficient post-MVP, indicating a sharp decline after MVP was implemented. AFJr's recent math scores have continued to decline and were at 58% math proficient in 2018.

   Performance at this school represents the IDEAL scenario for MVP (expert MVP author/teacher, all teachers on-board for MVP, on-site expert, real-time PD), and still, the results are declining. None or very few other Utah high schools use MVP.

Chart of Math Test Scores at AFJr (2010-2018):

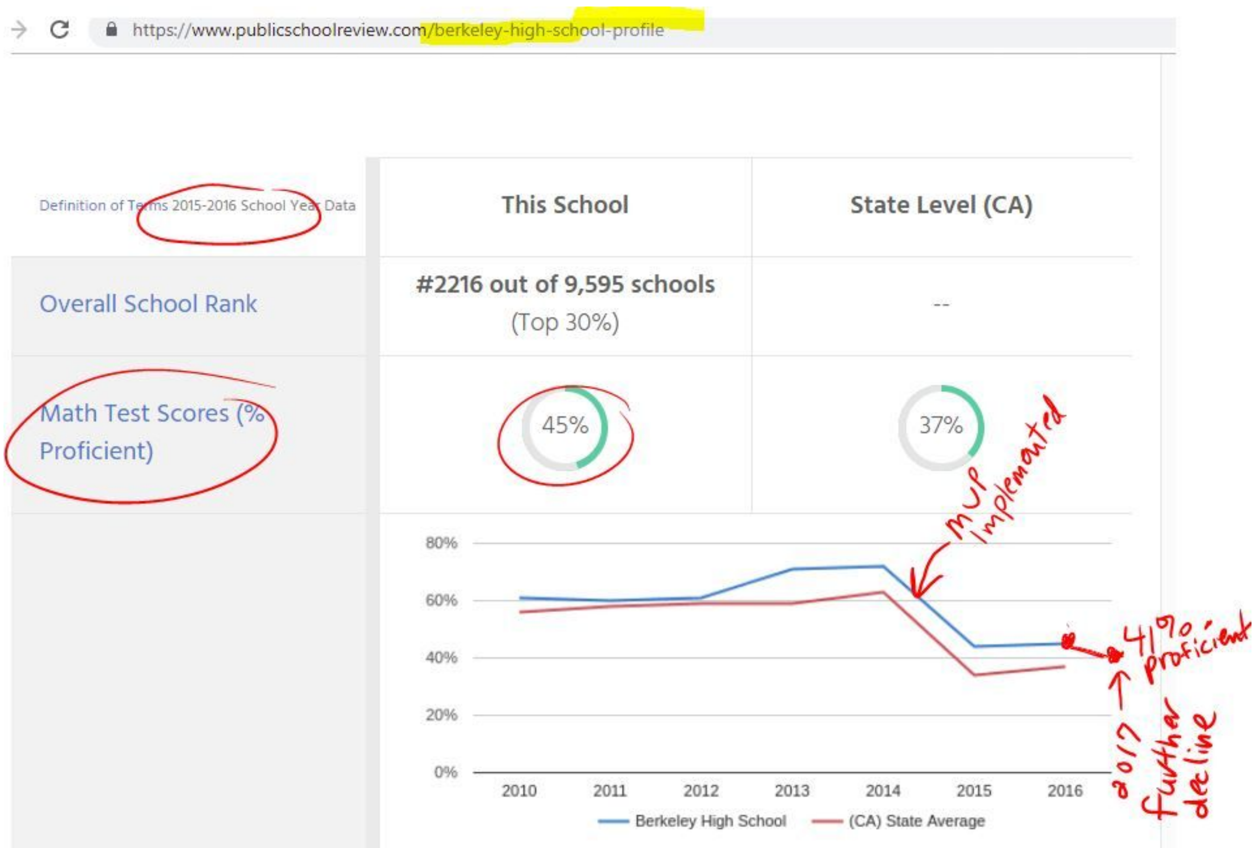


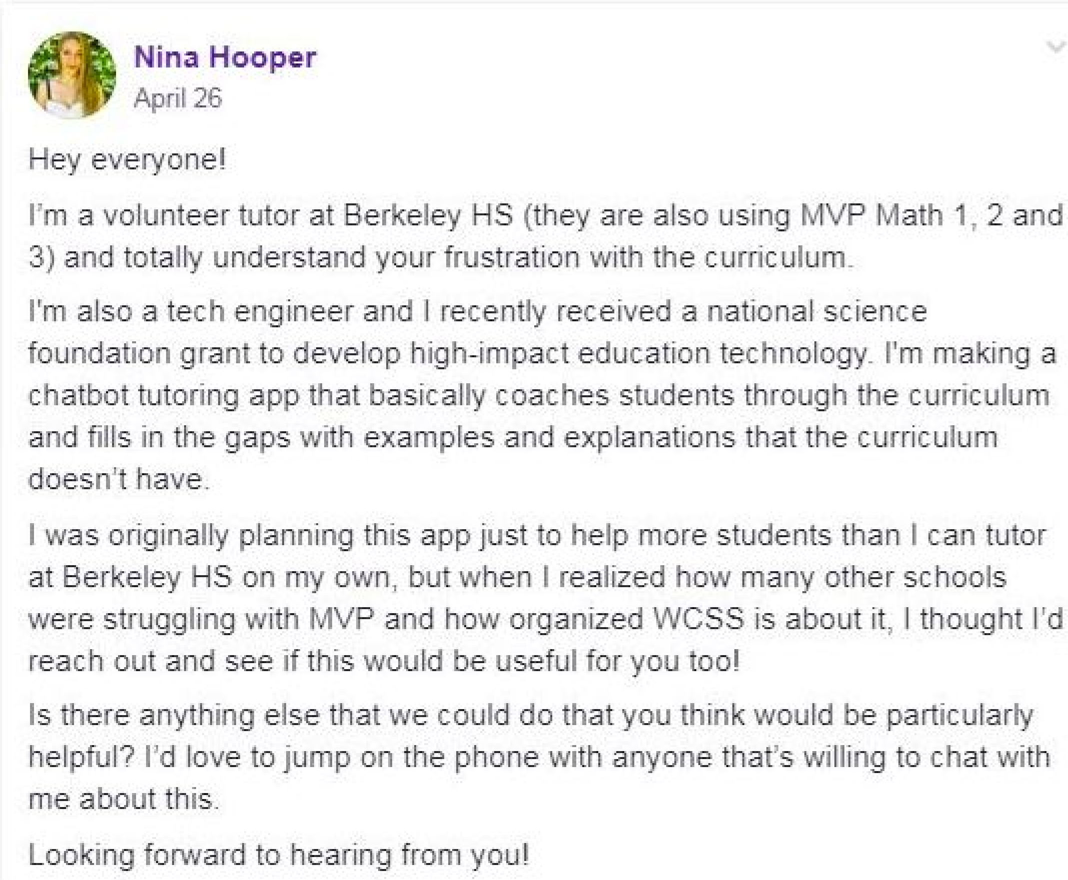
	% Proficient			
	2015	**2016**	**2017**	**2018**
American Fork Jr. High	58	60	56.4	57.6
American Fork High	53.8	47.3	42.5	36.4
Fairfield Jr. High	57.5	61.4	61	63.7



2. Berkeley High, CA - Berkeley High began using MVP in 2015. Since then, their math scores declined and flat-lined. In 2017, two years after MVP was implemented, their math proficiency declined to only 41% proficient. See 2017 scores here: [CA Dept of Ed- Berkeley (post MVP)](). Scores were much higher prior to MVP being implemented. See: [CA Dept of Ed -Berkeley (Pre-MVP)](). Also see article, ["The Math Crisis at Berkeley High"](). Also see article, ["Math Department Concerned by High Failure Rates."]() Also attached is a screenshot from a Berkeley, CA engineer math tutor where she states she is frustrated with MVP after trying to help Berkeley High students.

Chart of Berkeley High Math Scores (2010 - 2017):





Nina Hooper
April 26

Hey everyone!

I'm a volunteer tutor at Berkeley HS (they are also using MVP Math 1, 2 and 3) and totally understand your frustration with the curriculum.

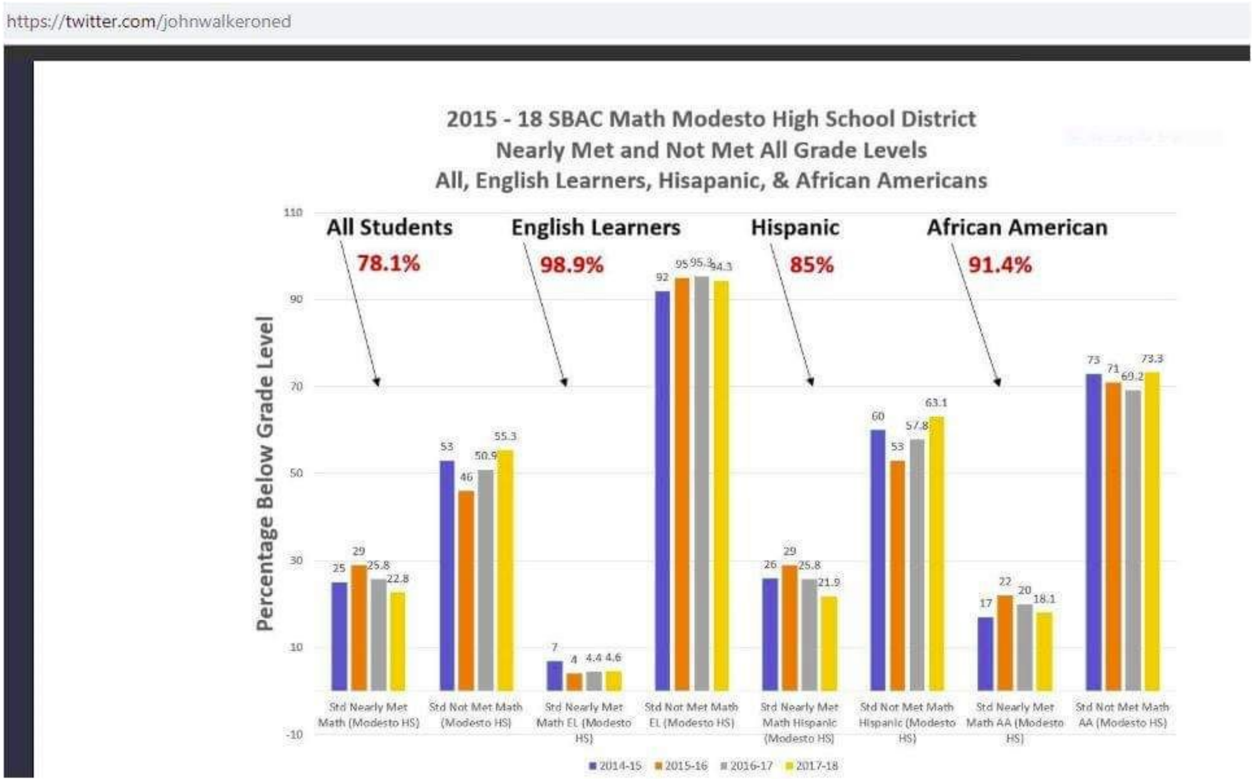
I'm also a tech engineer and I recently received a national science foundation grant to develop high-impact education technology. I'm making a chatbot tutoring app that basically coaches students through the curriculum and fills in the gaps with examples and explanations that the curriculum doesn't have.

I was originally planning this app just to help more students than I can tutor at Berkeley HS on my own, but when I realized how many other schools were struggling with MVP and how organized WCSS is about it, I thought I'd reach out and see if this would be useful for you too!

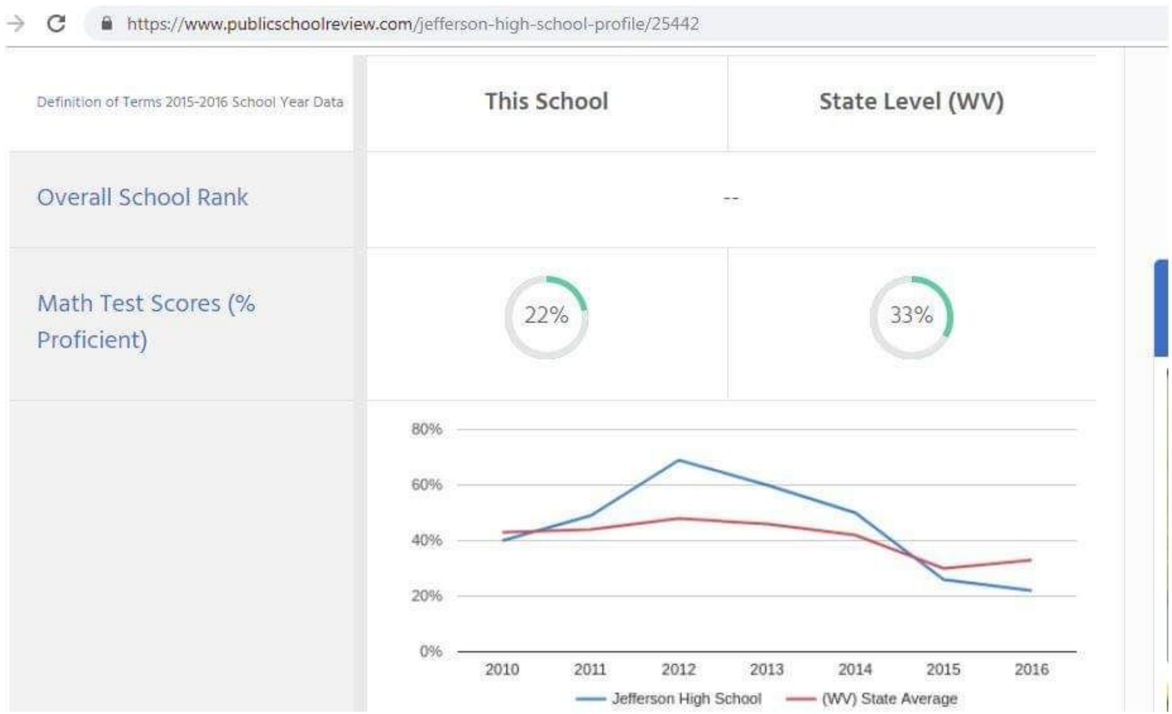
Is there anything else that we could do that you think would be particularly helpful? I'd love to jump on the phone with anyone that's willing to chat with me about this.

Looking forward to hearing from you!

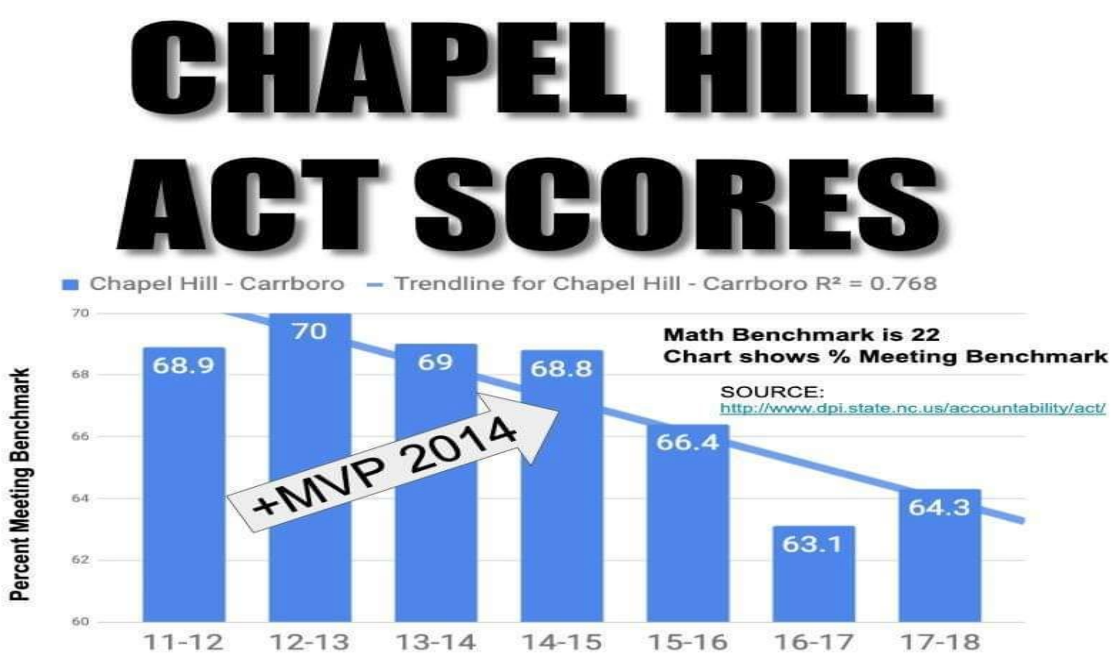
3. Modesto City Schools, CA - Several high schools implemented MVP in 2014-15. Some did not adopt MVP until 2017. California Department of Education data shows that in 2018, five years after adopting MVP, Modesto City High School's math proficiency dropped to only 22% proficient in math. See CA Dept of Ed and Schooldigger.com. Fred C. Beyer High School in Modesto adopted MVP in 2017, and their 2018 math test results showed only 29% of students were proficient in math. James C. Enochs High School adopted MVP in 2014-15, and in 2016-17 only 38% were proficient or advanced. At Enochs, 62% of high school students were BELOW proficient level in math. See USNews.com - Enochs High. Additionally, the Modesto City Schools School Board President and NASA Software Engineer, John Walker, is currently in the process of removing MVP in that school district due to declining math scores. He has compiled various charts on his Twitter page showing how MVP is particularly harmful to low-income students, African American students, Hispanic students, and English Learners. See Modesto chart below.



4. Jefferson County, WV - MVP was implemented at Jefferson High School in 2013-14 for Math 1, Math 2, and Math 3. The West Virginia Department of Education website shows that in 2016, two years after MVP was implemented, 11th grade math proficiency declined to 22%. See https://zoomwv.k12.wv.us/Dashboard/dashboard/7310. In 2013, prior to MVP use, math proficiency at Jefferson HS was 60% proficient. See https://www.publicschoolreview.com/jefferson-high-school-profile/25442 Jefferson HS experienced a steady decline in math proficiency following implementation of MVP in Math 1, 2, and 3 five years ago.



5. Chapel Hill, NC - In the Chapel Hill-Carrboro School System, high school ACT Math scores have declined steadily since MVP math was implemented. ACT math scores declined from 69% meeting ACT math benchmark in 2013 (pre-MVP), down to 63% meeting math benchmark in 2017 (post-MVP). See chart below summarizing NC DPI information.



III. The COST of MVP in Dollars

A. Updated Cost Information Released 7/8/2019

$1,440,353.00 as of 3/28/2019

$11,200 for Curriculum Writers (alignment, enhancements, corrections)
added
6/7/2019

Unknown Cost for 3rd party to independently evaluate the implementation of MVP and support the process of continuous improvement added 6/7/2019

$146,250 Professional Development cost for 2019-2020 (contract NOT approved by board as of 7/8/19)

$194,835 Cost of Printing Workbooks through Quarter 1 of 2019-2020 added 7/8/19

$62,500 Sub Cost for Professional Development for 2019-2020 added 7/8/19

TC

Timothy Simmons _ Staff - Communications
Me
Today, 6:22 PM
1 attachment

Hello Ms. Carter, I received the following information from the Academics Department while I was out last week. It is in response to your question below.

Regards, Tim

Tim Simmons

Chief of Communications

Schools received only Quarter 1 workbooks in the spring of 2019. Quarters 2-4 will be forthcoming throughout the year. Errors were corrected as the year proceeded.

Total cost of printing for 2019-2020 to date:
$194,835

Professional Development:
Contract with MVP to provide 25 days of Professional Learning: $146,250
Funds for substitute: $62,500.

IV. <u>Harm done by MVP</u>

A. Students' grade point averages have declined, affecting college entrance prospects

B. Monetary cost to parents in money spent on math tutors

C. Anxiety endured by students and parents over MVP math struggles

V. <u>Professional Concerns with MVP</u>

A. **LynneGregoria, Ph.D, Mathematics**, has been working in the field of mathematics education since 1989. She received a Ph.D. in Mathematics Education from North Carolina State University in 1998. She has taught everyone from Pre-K students to doctoral students. She runs a learning center in North Carolina where she tutors students in reading, spelling, writing, and mathematics. She has recently started developing curriculum so that she can reach a broader range of students across the nation. She is married and has 4 children.

From: Lynne Gregorio <lynne@zen5.me>
Sent: Wednesday, April 24, 2019 1:33 PM
Subject: Mathematics in WCPSS

Dear WCPSS,

Hi, I wanted to write to you with some thoughts about the current state of mathematics in the WCPSS. To briefly give a little bit of background, I have a B.S. and M.S. in Mathematics and a Ph.D. in Mathematics Education. I have taught at universities such as Meredith College, Wake Tech, and NCSU; I have also been tutoring WCPSS students in mathematics for over 20 years. [redacted]. So, I have witnessed the program when it was traditional (Algebra 1, Geometry, Algebra 2), switch to Common Core, and attended the information session when parents gave input into the new curriculum (MVP vs. the other option).

As a math educator, I understood the focus and intent behind Common Core and MVP. However, I have never felt it was the right fit for our students based on my empirical experience working with a wide range of students. So many kids in our schools struggle with mathematics and a direct instruction approach is needed vs. discovery learning. Adding components of conceptual understanding is very important, but it has been done (in many cases) at the expense of practice with procedural mathematics. The bottom line is that we are trying to do too much with the time we have. Discovery learning takes MORE time. Adding in conceptual understanding and time for kids to process this, takes MORE time and what WCPSS did was add all of this AND more topics to cover (Common

Core). So, the end result has been weaker and frustrated students graduating from our schools. Quality (mastery) has to become a priority over quantity.

There are many students who can handle the pace of starting Algebra 1 in 6th or 7th grade and progressing through Calculus 2 (or even Calculus 3) by the time they graduate, please allow them to do this, but also allow those that cannot, time to understand and process the math we give them. The topics in Math 1-3 should be split apart and covered over all 4 years to slow things down and instead of discovery learning, the WCPSS needs to investigate a mastery learning approach.

A mastery learning approach is one that does not allow students to move on to a new topic until a previous topic is mastered and able to be recovered at a future date (not just learned for the test and forgotten). Assessments are cumulative benchmarks each quarter. Students who need to go very slow, will take math EVERY semester during high school, other students might be able to take math just one semester a year if mastery is being obtained. Not only does mastery help students understand and be successful in math, it takes the pressure off teachers to give grades that don't represent student understanding, and it gives students a positive "math self-esteem," which will carry throughout life.

I hope, during this time of flux, as you are considering the future of math education in WCPSS, the idea of a mastery learning approach will be considered and you will move away from discovery learning (MVP) and trying to cover too much content at the expense of true understanding. Thank you for taking the time to read this.

Sincerely,
Lynne M. Gregorio, Ph.D.

C.
D.
E.
F. Hava Edelstein, Cognitive Researcher, Inventor, and Former WCPSS Student

Hava Edelstein's Response to the MVP Committee Notes:

July 8, 2019

To Access All Documents Referenced in the Following, Please Click Here.

Introduction

My name is Hava Edelstein. I am currently a Wake County citizen and a 1992 graduate of Enloe High School. While I lived 20 years of my adult life in California for career and education reasons, I consider Wake County my home. After all, I grew up here, attending JY Joyner Elementary, Hunter Elementary, Ligon Middle, and Enloe High, and returned "home" a few years ago, where I am fortunate to live close to both of my wonderful parents.

My life trajectory is a little unusual in that I worked for several years in the computer industry -- first in Cary and then in San Francisco, before earning a university degree (Bachelors degree) at age 35 (from UC Berkeley, in Cognitive Science, the interdisciplinary study of learning and cognitive processes).

My involvement in the MVP discussions came about after reading about the Green Hope walkouts. In the course of my life, I have spent hundreds of hours reading about math and computer science education, for academic, professional, and personal reasons. I am not an expert, however, I believe I am more educated on STEM and math academic literature than 99% of the population. Additionally, my opinions have been formed by my own STEM education and working in a STEM career as a coder and quality assurance engineer. (If you google "Hava Edelstein patent", you can even see my name as one of four on a technical patent based on technology I co-developed in my twenties.)

My interest in the MVP issue is also influenced by my identity as a "twice exceptional" learner. This means that I have both amazing gifts and amazing challenges. It was not until adulthood that I fully understood the neurological challenges I faced and found

ways to overcome them. Thus, in high school, I earned only a 2.5 GPA (unweighted), failed many classes, and made the honor roll only one semester out of eight.

After much self-education as an adult, professional help, and very minor accommodations in school, I received a 4.0 during two years at San Francisco community college, and then transferred to UC Berkeley on a Regents' and Chancellor's Scholarship -- the highest academic scholarship that this prestigious university offers. At UC Berkeley, I took classes in math, computer science, cognitive science, linguistics, and psychology, worked in a research lab, and learned so much about myself, about research, about education. I am so fortunate and blessed to have had this wonderful opportunity, whatever age I got there!

My personal story is a little unusual, but it speaks to the power of self-knowledge, and how understanding how one learns and processes information makes all the difference in the world to either failing or succeeding.

And on this issue of information processing: I firmly believe that MVP is not the best choice for Wake County students, and that the struggles we hear about from many parents and students are not isolated incidents, but instead experiences that have been repeated by many students around the country in many reform curriculums for many years. And throughout this document, I will provide many literature reference that bear out this assertion.

My own position is that I advocate for a balanced math curriculum that has worked examples, clear written explanations, multiple representations, productive struggle, and a mixture of teacher-led instruction and collaborative group work. All of these things! Neither the classic "traditional" math curriculum nor MVP fits such a description.

But such a discussion of my absolutely "ideal" math curriculum is beyond the scope of this document.
Edelstein (cont'd)

In the interest of space and time, my purpose here is simply to refute some of the committee statements in support of MVP by bringing prominent, influential, and highly respected and highly educated voices into the discussion.

Groupthink and Confirmation Bias

My purpose in reading the committee notes and taking the time to refute them is because I want the best for all Wake County students, and in reading the committee notes, I came to believe that some authors of the document may possess an incomplete understanding of cognitive science or education literature.

I would like to add that I am very thankful for everyone who spent time on the committee, and devoted their time and energy to the task, but I think it is also important for Wake County decision makers to understand that many experts across the country with very impressive research credentials and academic degrees have reached very different conclusions.

And in reading the committee notes, I am personally somewhat dismayed by the amount of times the answers to the parent concerns quote marketing material directly from the MVP site or other MVP sources. To me, part of the "critical thinking" we wish to embrace in the 21st century is about critically examining claims and evidence.

When a company has a vested interest in promoting a certain position — even a nonprofit company — they may not be the most neutral and reliable source of information. It is important and necessary to seek out other sources of information, and in particular, to purposefully seek out conflicting information and opinion. Otherwise, we are claiming to formulate an "informed opinion" by informing ourselves only with information that agrees with our point of view. This phenomenon is called "confirmation bias", and is taught in both business and psychology classes as something that needs to be avoided if seeking to make the best decision possible.

In this response document, it is not my goal to convince you that my position — or any one particular position — is the absolute "right" and "correct" position. It is instead my goal to expose you — assuming "you" are a Wake County decision maker — to more neutral sources of information (such as peer-approved academic research) that can be readily and easily found and may cast some doubt on whether Wake County has made the best decision possible with the MVP curriculum. I am attempting to ameliorate a
Edelstein (cont'd)

confirmation bias that seems already to have taken hold. And you may still choose to make the exact same decision, but if that it the case, it will at least be with the knowledge that other points of view and information have been seen and considered.

I will now respond to a few specific points of the committee notes, with the understanding that a comprehensive response would be dozens of pages long, and a shorter length is more ideal. (Thus I have picked only a few points to refute, to keep my response under 20 pages.)

With the idea that I am not including all of the ideas or knowledge in my head, if you wish to learn more details about any of the points herein, or wish to have more evidence or sources for any of them, or if I have failed to source something to your satisfaction, please email me at hava@berkeley.edu and I may be able to provide you with what you need. Keeping in mind that this is volunteer work and I cannot always respond right away, I will endeavor to provide any Wake County representative who emails me with some sort of response within 48 hours.

Now we get down to the nitty gritty. For the rest of this document I will quote some of the committee notes and attempt to add a broader perspective.

Specific Refutations

Quote 1 (under the Violation 1 Section):
"I think it's also important to note that this is a program that has been adopted in other areas of the county as well as within our own state. Other districts must believe this is a sound educational resource."

Response:
When evaluating a new curriculum, I believe it is more important to look at the *actual results* of the program (that is, the *impact* of the program) as opposed to mere beliefs about the program, in other words, the *intention* of the program).

But this is an interesting philosophical debate, and maybe I am wrong; maybe it is the *intention* that matters more than the *impact*.

Instead of trying to settle this debate, I am just going to present an intention vs impact case study. Please see the material in the "SoledadHigh" folder. This includes an essay written in 2017 about all the great reasons that Soledad High chose the Mathematics Vision Project as the best curriculum for the school. And there are so many good reasons! Such good intentions! Such wonderful research about why it is the best choice!

Also included in the folder is a ReadMe.pdf file with a summary of the *actual* results. After implementing the Mathematics Vision Project curriculum at this struggling school, standardized test scores dropped non-trivially.

It is not unusual in wealthier districts for parents to pay for private tutors after their schools or districts implement the MVP curriculum, and there are abundant cases of this happening, such as Wake County or Berkeley High School (in Berkeley, California).

But Soledad High School is full of low-SES students whose parents overwhelmingly cannot afford tutors. And in other schools or districts, while private tutors can cloud the issue, at Soledad High School there is no such confusion or clouding of the results. Under MVP, rade level proficiency fell from 16% to under 10%, and the amount of students scoring a 1 (the lowest score) on the statewide CAASPP test rose from 59% to over 70%.

To return to the original quote: "Other districts must believe this is a sound educational resource". This is true; they do. But that does not mean that it actually is; to evaluate whether it actually is, perhaps it is better to look at educational research and actual curriculum results. Sometimes doing what everyone else is doing is a good strategy, and sometimes it is not.

Quote 2 (under the Violation 1 Section):
"In response to computational skills must be developed first- Research findings show that difficulty in one domain- problems solving or computation- does not necessarily align
with difficulty in another. Problem Solving and Computational Skill: Are They Shared or Distinct Aspects of Mathematical Cognition?
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2802329/"

Response
This reference is to an interesting paper that concerns third grade math skills, and does in fact find that computation and problem solving skills are not necessarily correlated. And I do not disagree with this point.

However, a high school curriculum has many more skills and subskills than just

"computation" and "problem solving". For example, if a student reads a word problem, the student must be able to isolate the relevant parts of the problem (skill 1), convert the

relevant parts into the symbolic language of algebra (skill 2), and then must use algebraic manipulation to isolate the variable on one side of the equation (skill 3), and finally, compute the exact value (skill 4) for the variable.

It is possible to use a calculator to do any computation that the problem requires (skill 4). And it is possible nowadays to even skip any algebraic manipulation at all (skill 3) by simply entering the equations into the calculator and having the calculator solve for the variables. But the student must still be able to set the problem up and even more importantly — *just because a calculator is capable of solving for x does not mean that this option is an ideal one*.

Advanced skill in algebraic manipulation is vitally important in university-level math. As someone who has taken Calculus, Linear Algebra, Differential Equations, and Discrete Math, I can attest first hand that it would not have been possible to pass these courses without fluent skill in algebraic manipulation.

So I believe that this reviewer misses the mark here. Parents are complaining that their students are being asked to do MVP word problems without learning the “basic skills” needed to do these problems first, for instance, they are being asked to set up and solve word problems without first mastering algebraic manipulation. Equating “basic skills” to only computation is too simplistic for a high school curriculum.

Computation alone is not the issue here, it is rather the broader idea that students are asked to work on word problems that involve many tiered subskills, and that it is difficult to tackle word problems under these conditions. It also leads to a severe lack of fundamentals, and the next section explores further.

Quote 3, under Violation 2 section:
“The argument is in favor of direct instruction without any strong evidence supporting the claim. It is well-documented that, on average, students in classes using reform curricula perform comparably to students in traditional classes but with a higher performance on tests of conceptual understanding (Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000…”

Edelstein (cont’d)

These statements are misleading at best and patently false at worst.. While some documentation exists that shows what this assertion claims, there is also a very large

abundance of research that does not agree or shows exactly the opposite. Educational research is funny that way; you can find studies that prove almost anything. And thus it is necessary to take a broader view instead of just focusing on a few studies here and there.

In my folder “ReformBroaderPerspective”, I have nine separate refutations to this assertion that reform curriculums produce equal or superior results. Here is a summary of the evidence:

000a.jpg and 000b.jpg:
These are screenshots taken from the first study mentioned in the author’s assertion above (*Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000)* , the study that is supposed that is supposed to show the *superiority* of a reform curriculum. At best, this study shows that students in a reform curriculum vs traditional curriculum *excel at different things*, not that a reform curriculum is superior. The abstract clearly states that students in a more traditional curriculum excel in “manipulation of symbolic expressions”. A particularly concerning detail shown on the second screenshot is that only 49.4% of students using the reform Core-Plus curriculum can solve this particularly simple algebraic equation when they are not using a calculator:
$3x + 4 = 5x - 2$. I also find it concerning that only 84.8% of the traditional curriculum students can solve it, but still: this percentage is considerably higher than 49.4%. What is clear is that the Core-Plus reform students do not “perform comparably” on algebraic manipulation as the committee reviewer asserts. Their performance on algebraic manipulation is clearly inferior.

0001a.pdf and 0001b.pdf:
These are both articles from three notable cognitive psychologists on why discovery learning (the type of learning prominent in the MVP curriculum) is often inferior to other forms of instruction. The articles are very similar and identical in some places, but are written for different publications in 2006 and 2012; one is more scholarly and one is more user-friendly; you can read either one or both as you prefer.

0002a.png and 0002b.pdf:
The png is a screenshot of an abstract that compares unguided discovery vs guided discovery vs explicit instruction, and the pdf file is the full article. It is notable that
Edelstein (cont’d)

“guided discovery” such as worked examples are considered superior to the unguided discovery more typical in the MVP curriculum. In fact, the MVP curriculum is notable for

leaving written examples out of their curriculum!

(And while students can turn to online sources, these do not always match up exactly with the MVP lessons, creating a great deal of confusion and wasted time. Particularly, some of the Khan Academy videos assume prior knowledge that has not yet been covered in the MVP curriculum. Written worked examples incorporated directly into a curriculum are vastly superior to mismatched online sources.)

0003a.png and 0003b.png:
These are screenshots of pages of an important research study out of Duke University. The purpose of the study, as the abstract states, is to investigate the effects of different sorts of reform practices in science and math education, by studying junior high students across North Carolina. But buried within pages and pages of complex statistical analysis is a surprise. Perhaps this “surprise” did not meet the expected outcome of the study, which is why it is not mentioned directly in the abstract. It is simply this: explicit instruction in the classroom showed a higher correlation to student success than most all of the reform measures. Particularly telling is this line: “*This form of pedagogy supports explicit instruction as an integral part of STEM learning and provides caution against shifting to an unguided, student-centered learning environment.*”

0004.pdf: An article called “Sage on the Stage” from “Education Next” in 2011 makes the case that the class lecture, while getting a bad rap nowadays, actually leads to superior student achievement.

0005.png: This is a screenshot of an abstract of a research study done with 112 third and fourth graders where direct instruction outperformed discovery learning in the science domain. It is not difficult to find such studies. (While I understand we are dealing with high school math and not elementary level science, I include this study as one strand amongst many to refute the committee member who asserted that reform-based curriculums are always equal or better than alternative curriculums.)

0006.pdf: This is a research paper by the notable UC Berkeley mathematician H. Wu (now retired) that argues that reform math curriculums dumb down math in such a way that students are not properly prepared for the rigors of university level math. He argues

Edelstein (cont’d)

that instead of helping students to be “career and college ready”, such curriculums have the exact *opposite* effect.

0007a.png and 0007b.png: This is a research study called “A study of Core-Plus students attending Michigan State”. True to Wu’s assertion, the study asserts that the more years a student participated in the reform math curriculum “Core-Plus”, the greater the chance they would place into remedial math at Michigan State. The pdf file is the full study and the png file is of a key table in this study. I will add that the Core-Plus authors refuted this study by claiming that the students were using a version of Core-Plus that was still being developed. That may be a fair criticism. But I would add then that Wake County Students are using a version of MVP that is, to my understanding, still being developed and polished.

0008.pdf:
This is a link to an article from the Christian Science Monitor, the only non-academic article in this bunch. It describes the implementation of the reform “Core Plus” curriculum at Andover High School, one of the most exclusive prep schools in the United States. There is a particularly compelling anecdotal report in this article of a student who aced her reform “Core Plus” classes at Andover, and then placed into remedial math at the University of Michigan. Normally, I wouldn’t give any anecdotal story much weight, but when a student at one of the best prep schools in the United States is placing into remedial math in college, I do have to wonder what exactly is going on, particularly when her story is part of a larger pattern.

0009.pdf:
This is a controversial paper that refutes a prominent study by Jo Boaler, one of the leading proponents of a reform math education. Here is my take on this paper: Professor Boaler’s dataset is private, and any attempt to reconstruct it is only speculation. Thus, when these researchers claim she is comparing disparate groups of students, I do not put any stock into their claims because we cannot know for sure. However, when they make claims that are publicly verifiable, such as the SAT scores of the schools, the result of AP Calculus tests, or remedial rates in college, I give those weight. The upshot is that Professor Boaler described the “superior” results of a reform curriculum in her original paper, based on a self-created assessment and other arguably subjective measures. Professors Milgram, Bishop, and Clopton point out that the average SAT score for this “superior” group is only 460, and that 61% placed into remedial math at Michigan State (vs a state average of 37%). Thus, the “superior”
Edelstein (cont’d)

results of the reform curriculum are called into question.

I debated including this paper because I respect Professor Boaler and especially her YouCubed site, which has many valuable math activities for students, and I love how she wants to create a positive environment in the math classroom. But at the same time, object results matter too.

It is notable that Professor Boaler is mentioned numerous times in the committee notes. Indeed, she has many valuable things to say and contribute. But I have to wonder, if we copy her reform methods exactly, will we also get 460 average SAT scores, and a 61% remediation rate when our students enter state colleges?

Quote 4, under "Violation 2" section:
"Theoretically speaking, Vygotsky's (1978) provided insights on the importance of constructing
knowledge through social interactions, which are characteristic of classroom environments."

Vygotsky did provide such a theoretical base.

And since Vygotsky's time, a great deal of cognitive science research — in fact, an overwhelming plethora of research — has been done on ideal learning conditions.

One particular important strand is the idea that learning can be constrained by a person's "cognitive load" — a concept which refers to the cognitive resources available in a person's current working memory.

Another important and related strand is the idea that training a person on different skills is often more effectively done if the skills are trained at different times. Along these lines, social interactions and in particular communication and collaboration can be considered one type of skill, and math skills are a different type of skill.

It is still possible to believe in the vital importance of the four Cs for 21st century life *and* to believe that practicing these skills *while* learning new and difficult mathematical concepts may not be the most ideal or effective or sensible way to learn or practice either skill.

Edelstein (cont'd)

But don’t take my word for it. A paper out of Carnegie Mellon called *“Applications and Misapplications of Cognitive Psychology to Mathematics Education”* (http://act-r.psy.cmu.edu/papers/misapplied.html) explains it better (italics are my own):

> The claim that instruction is only effective in a highly social environment is based on the ideas that (a) virtually all jobs are highly social in nature and (b) learning is closely associated with its context. As we have shown, the second claim is overstated. We suspect that the first claim is also somewhat overstated, although we are not acquainted with any analyses of existing job surveys that show how much social interaction, and what kind, is involved in various jobs. Clearly, there are jobs that are not social in character and for which this claim does not hold. Likewise, it is clear that there are jobs where performance is highly social. Obviously it is important that people with such jobs learn (within or outside the specific job context) to deal effectively with the social nature of their jobs.
>
> While one must learn to deal with the social aspects of jobs, this is no reason why **all** skills required for these jobs should be trained in a social context. *Consider the skills necessary to become a successful tax accountant. While the accountant must learn how to deal with clients, it is not necessary to learn the tax code or how to use a calculator while interacting with a client. It is better to train independent parts of a task separately (see the earlier discussion of nearly independent subtasks under decontextualization) because fewer cognitive resources will then be required for performance, thereby reserving adequate capacity for learning.* Thus, it is better to learn the tax code without having to simultaneously interact with the client and better to learn how to deal with a client when the tax code is no longer a burden.
>
> In fact, a large history of research in psychology shows that part training is often more effective when the part component is independent, or nearly so, of the larger task (e.g., Knerr, Morrison, Muman, Stein, Sticha, Hoffman, Buede, & Holding, 1987; Patrick, 1992). Indeed in team training, it is standard to do some part-task training of individuals outside of the team just because it would be expensive and futile to get the whole team together when a single member needs training on a new piece of equipment (Salas,

> Dickinson, Converse, & Tannenbaum, 1993). In team sports, where a great deal of attention is given to the efficiency of training, the time available is always divided between individual skill training and team training. We will have more to say about the issue of part versus whole training when we discuss the constructivist advocacy of carrying on all instruction in complex learning situations.

Quote 5, under “Violation 10”:
“My students are succeeding and the majority could not afford a tutor; therefore, I disagree with the glaring inequity. Staying after school to receive help from a teacher is free. Meeting with the teacher before school is free.”

This is an anecdotal report of one teacher and one set of students. Some teachers (like this particularly teacher) might be particularly good at using this particular curriculum, and some may not be. It is *very unfortunate* (and very unempathetic) that this teacher considers anecdotal evidence to be robust evidence.

In some schools, teachers do not have good facilitative skills; others cannot stay before or after school; and yet in other situations, students have no means by which to arrive early or stay late.

Consider:

Do *all* students have transportation and family situations such that they can easily stay after school or arrive before it?

Do *all* students have access to teachers willing to be available for private tutoring before school, after school, or during lunch, as the student needs?

Do *all* students have access to private tutoring with their teachers -- or do they show up to find five other students needing tutoring too?

It is a *severe and horrendous disservice* to many students to say that just because a certain teacher and a certain set of students are succeeding, that means that everyone else has equal access to the resources needed to succeed.

Edelstein (cont’d)

Indeed, several parents in Wake County are currently paying for private tutors to help with the MVP curriculum. Many of these students have older siblings such that their older siblings in a differing curriculum *did not require tutors*. And while parent reports *are* only anecdotal, I believe it is fair to bring them up considering this teacher's experience is *also* anecdotal. Many parents on our facebook group report spending *hundreds of dollars a year* on private tutoring for their students, in order that they can do their nightly homework and/or pass the class.

Do *all* students have families that can spend hundreds of dollars on tutoring?

Please also note also that spending money on private tutoring when using reform discovery-oriented curriculums in schools is not at all unusual! Please see the document "A Brief History of American K-12 Mathematics Education in the 20th century" in the "MathWarsHistory" folder to learn more about this, and in particular, what happened when a reform math curriculum was used in the wealthy Silicon Valley area. As one parent described a reform math situation from the 1990's:

> Palo Alto School District parents are sufficiently discontented with the district's math performance that in massive numbers they are resorting to outside math tutoring programs. Forty-eight percent of parents report providing outside help in math for their children (in the middle schools, this number rises to 63 percent). The math-basics group HOLD's own informal survey of the best-known commercial math programs shows that Palo Alto parents are spending at least $1 million a year for math tutoring (Evers, 1995).

Quote 6, under "Violation 3": *"Parent information on errors from teachers/tutors are not necessarily errors but instead a difference in teaching methods/approaches."*

They are not necessarily errors. But some of them certainly are!

And most concerning are cases where the MVP curriculum designers or Wake County administrators stand behind such errors as methodological differences when 100 out of 100 mathematicians would agree that they are in fact errors.

I cannot speak to the errors that were submitted to the committee because the style and formatting of the committee response document does not list out the (real or supposed)
Edelstein (cont'd)

errors. But I can speak to one that I found, and the supposed reason for it, and I assert with confidence that it *is* an error, even if it continues to be justified as purposeful because it creates an easier lesson for the student.

To understand what I am speaking about, please see the folder "MVP Created Definition" for evidence that MVP has changed the definition of the "Point Slope" form of the line. What is worse is the supposed reason for changing it: to make the algebraic manipulation easier. By changing the definition from:

$y - y1 = m(x - x1)$

to

$y = m(x - x1) + y1$

the task of converting from one form of a linear equation to a different form has been made easier for the student. (A Wake County parent asserted that this definition change is purposeful and deliberate; I have every reason to believe she is correct; otherwise, the mistake would have been corrected many months or years ago.)

To be clear, changing a math definition for a particular lesson is horrendous math practice. And the student is not told that the definition has been changed! As my document MVPWrongDefinition.jpg shows, every single other math source that I looked up uses the correct definition, including Khan Academy. How confusing it must be for the student to see one definition on Khan Academy and another in the MVP workbook!

Even worse, students are learning that mathematical definitions are mutable things that can be changed depending on a particular exercise or lesson! This is a terrible practice especially for mathematical proofs, when the sanctity of math definitions is especially important.

I have noticed that parents without STEM backgrounds are less upset about this than I am. Let me give a comparable example:

Imagine a child taking a ballet class, and learning the ballet positions. The teacher decides that "second position" is too difficult for her students, so changes it without telling her students. Then the practice is defended as a stylistic teaching difference.
Edelstein (cont'd)

In this particular MVP “stylistic difference”, we see a crucial curriculum decision being made: either: we can either ask the student to develop *a very basic level of algebraic manipulation* so that they can transform one linear form into another, or we can change the definition of one of the forms to make the algebraic manipulation that much easier, so even a basic level of algebraic manipulation is not required!

The MVP designers -- typical of these more radical reform curriculums -- chose the latter choice. And decisions like this are why UC Berkeley Professor Emeritus Hung-Hsi Wu believes that many reform math curriculums cannot possibly adequately prepare students for career and college readiness.. In college math, definitions don’t change (!) , and problems are not altered for the student in order to reduce the need for basic algebra. (!)

A Special Note to Dr. Martin

Dr. Martin, it is my impression that you support the MVP math curriculum. And so it is for you in particular that I would like to pose a question: suppose a student was taking one of your famous chemistry exams -- known for being conceptually difficult -- and wrote this note to you or a grader:

“This problem deals with the element sodium. For this problem, I am going to redefine sodium to contain 12 protons instead of 11 protons because it fits my needs better and allows me to solve the problem easier. I learned in my MVP math curriculum that definitions can be changed to make problems easier, because the MVP designers changed the “Point Slope” definition of a line to make a math exercise easier. If they can do it, I can do it too! So sodium has 12 protons and thus the solution is…”

Would you accept this reasoning Dr. Martin? Would your grader? If the answer is No, then can I ask you to think about your support for a math curriculum that supports this practice? The incorrect Point Slope definition is *not* a mistake in the workbook; it is a purposeful decision that reflects a much greater set of priorities in play.

In any case, thank you for your time and dedication and effort to your students, your chemistry students and all of Wake County’s students. Thank you for considering this point, whatever your decision may be.

Bonus Section: Gradation is Better Than Dichotomy

I would like to leave a final note on the unfortunate dichotomy I see frequently expressed between a "traditional" curriculum and a "reform" one. Yes, curriculums and teaching styles do exist on either end of the spectrum. But I believe it is better to view curriculums and classroom practices on a gradation instead of an either/or paradigm. In the "RefutingDichotomy" folder, please find a document called "Gradation Description" from an education blog (source: :https://4mathlearning.weebly.com/dl-vs-di.html) that contains a rich gradation description:

> The discovery learning - direct instruction debate is referring to the explicitness of lesson and unit design, which falls along a continuum from endogenous constructivism (learners discover their own knowledge, very extreme) to dialectical constructivism (teacher-guided exploration that is interactive) to exogenous constructivism (direct instruction where students are responsive and engaged) to reductionism (rote instruction where learners are rather passive, also extreme). Most teachers with diverse classrooms will plan lessons in the exogenous to dialectical ranges, planned and guided by the teacher, while ensuring high levels of student engagement (Gurganus, 2017). Curriculum developers and mathematics educators, with some radical exceptions, now support this balanced view for teaching and learning (Cole & Washburn-Moses, 2010; Hennessey, Higley, & Chestnut, 2012; Hudson, Miller, & Butler, 2006; National Mathematics Advisory Panel, 2008).

So as we continue to talk about pedagogy and educational practices, let us aim to discuss the issue more creatively than "reform" or "traditional", and instead understand the very rich possibilities, techniques, and practices all along the spectrum.

And it is important also to note that both "traditional" and "reform" methods can be used together in creative and wonderful ways. The research experiment "Explaining self-explaining: A contrast between content and generation" (located in the same folder) is such an example: it combines a more traditional technique (studying examples) with the idea of discovery, via discovering broader patterns (via explaining). There are so

many creative possibilities for how to teach Wake County’s students, let us never be constrained to overly simple “traditional” or “reform” discussions or decisions, and consider instead how to combine different research-based techniques into the most engaging and effective instruction possible!

B.

From: Sara Scanlon _ Staff - ApexFriendshipHS <sscanlon@wcpss.net>
Date: Monday, October 29, 2018 at 5:09 PM
To: Cathy Moore <cgmoore@wcpss.net>
Subject: MVP Concerns

Ms. Moore,

I hope this email finds you well. Let me begin by saying I am not writing this email to complain about new curriculum. In my short seven years of teaching high school math, I have taught traditional math courses (Algebra I, Geometry, Algebra II), Common Core math courses, and now, MVP math courses. I am no stranger to new curriculum, and I believe change is imperative to progress.

First, I want to highlight the outstanding features of the MVP curriculum. I have seen how learning through productive struggle has cultivated my students' ability to make real-world

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Educational Research Articles

1) Please read the entire article by Frank Quinn*: Reform Mathematic Education is Counterproductive for High-Tech Careers (And It’s Not the Teachers).* The following are a few key points extracted from Quinn’s article related to why discovery-based math is not in the best interest of students:

“Development of fast, accurate, and transparent skills has been explicitly deemphasized in the reform curriculum (cf. “drill and kill”). Rather than requiring memorization of the quadratic formula, “barriers are lowered” by using quadratics with integer roots that can be easily factored. The focus is almost exclusively on polynomials with numerical coefficients, so the more realistic examples with symbolic coefficients seem completely alien.”

“It is possible to get students to refine pattern-in-examples learning, but it is tedious and difficult because students have to be told repeatedly that they are wrong, and have to be willing to spend a lot of time trying to figure out why and how to fix it'. The discipline and engagement necessary to get functional outcomes are rare in the general student population. The level of discipline needed is unacceptable in reform education, and the expertise necessary is rare among teachers of any stripe. In practice, therefore, the tech deficiencies of discovery based learning are not corrected.”

“Students taught mathematics at the pattern-in-examples level often get stuck there. Advancing to the systematic methods and algorithms requires not only un learning the dysfunctional heuristics they discovered for themselves, but unlearning the approach to learning that produced these dysfunctional heuristics.”

“Reform-trained students often rely more on pattern-in-example associations ("discoveries') than on careful step-by-step reasoning and use of algorithms. Their reasoning skills are rarely strong enough to refine or even filter the pattern-matching process, and are inadequate for extended or unfamiliar problems. They are doomed to fail advanced courses. The most painful aspect for a teacher is that they can't even identify why they fail, and go away thinking they must be stupid. But this isn't true: anyone who can get to second-year engineering calculus using pattern-in-example learning is not stupid.”

“In the reform “dialogic” approach, understanding is supposed to precede skill or precise concepts. Students are given heuristic explanations, examples and other hints, and are invited to synthesize or discover their own concepts. But the results have almost no chance of being functional: remember that it took gifted professionals centuries to extract themselves from all the subtle dead ends. I saw this in action in the late nineties when I taught from a reform text for several semesters. Most of the students failed to synthesize much of anything, and what they did come up with rarely supported material in the next course. My current students have been indoctrinated to believe memorization is 'wrong', so they find it almost impossible to take even the first step of the process that professionals find effective. They lack the logical skills needed to recognize and fix dysfunctional concepts, so even good students arrive at the college level with deeply embedded confusions about elementary material.”

“To teach someone to use a hammer, have them drive a lot of nails. Asking them to “understand' or 'discover' hammers essentially guarantees confusion and poor

skills."

About the author: Frank Quinn- He received a bachelor's degree and a master's degree from the University of Virginia, and Ph.D. from Princeton University. A member of the Virginia Tech community since 1977, Quinn made significant contributions to the understanding of the topology of manifolds and related areas of topology. His research was published in the leading mathematics journals and he frequently was an invited speaker at the International Congress of Mathematicians and in Conference Board of the Mathematical Sciences lecture series. Throughout his career, Quinn engaged many of the best mathematicians of the late 20th century in a stimulating, high-profile dialogue on the direction of the profession. He organized several mathematics conferences and special sessions, served on five committees of the American Mathematical Society, and served on the Council of the American Mathematical Society. In addition, he held editorial roles with the Bulletin of the American Mathematical Society and was a member on a national K-12 mathematics standards panel. Quinn also wrote educational software that was used by thousands of Virginia Tech students. Quinn was elected a Fellow of the American Mathematical Society and was selected as a Fellow of the American Association for the Advancement of Science.https://vtnews.vt.edu/articles/2015/04/041015-science-emeritusquinn.html

Please read Barry Garelick's, *Drilling "Rote Understanding" below:*

Over the last several years, the press and television have publicized many parents' frustration with how math is being taught in the lower grades. On the internet, videos abound with examples of how procedures such as addition and subtraction are being taught to students using convoluted methods that are leaving students and parents baffled as to 1) how to do the procedure and 2) angry that the standard methods are delayed. (This video is one of many examples of parent concern over how math is taught under Common Core.)

The current interpretation of Common Core by publishers, instructional coaches, professional development vendors, and other educational entities, maintains that teaching the standard methods (known as standard algorithms) for various procedures too early can eclipse the conceptual underpinning of why the algorithms work, and can lead to students being confused. A video by one instructional coach argues that teaching only procedures 1) has only worked for a small group of students and 2) that the reason students have a hard time with math is "No one taught them to understand

the concepts and why we're doing what we're doing. We didn't teach them how to think; we just taught them how to 'do' and execute…" The premise stated by this coach and others, contains the usual mischaracterization that procedures were taught in a void without contextual understanding. He also maintains that Common Core's main focus is on "understanding". This article explores this notion, and how and why Common Core is interpreted and implemented in the ways we are seeing.

A case in point

A case in point has presented itself in my recent work with a group of fifth graders in need of math remediation at the school where I teach. The students were doing exercises from their textbook on multiplying fractions. Instead of applying the standard method (or algorithm) in which numerators are multiplied by numerators and denominators multiplied by denominators, students first had to draw diagrams for each and every problem.

The diagrams I speak of have been used in many textbooks as a means to motivate the particular procedure for multiplying fractions. Such diagrams use the area of a square as the means to illustrate what multiplication of fractions represents, and why one multiplies numerators and denominators. For example, a problem like 3⁄4 × 2⁄3 is demonstrated by dividing a square into three columns, and shading two of them, thus representing 2/3 of the area of the square. Then the square is divided into four rows, with three of them shaded–this is 3/4 of the area of the square. Where the two shaded areas intersection therefore represents 3/4 of 2/3 of the square. The intersection of the two yields 6 little boxes shaded out of a total of 12 little boxes which is 6/12 or 1/2 of the whole square. This is done as the reasoning—the conceptual understanding—behind multiplying numerators and denominators.

The students see what 3/4 of 2/3 means in this model in terms of area of a square.

Nothing New Under the Sun

This was the explanation used in my old arithmetic book from the 60's (and in other textbooks from that time and earlier times thus belying the notion that traditionally taught math ignores understanding and focuses only on rote memorization.)

The method used in my old textbook is also the method used in Singapore's math

textbooks. It is an effective demonstration of what fraction multiplication represents and why one multiplies numerators and denominators. In Singapore's textbooks (as in mine), students are asked to use the area model for, *at most*, two fraction multiplication problems. Then students are let loose to solve them using the algorithm.

But in the current slew of textbooks claiming alignment with the Common Core, after the initial presentation of the diagram to show what fraction multiplication is, and why and how it works, students are then required to draw these types of diagrams for a set of fraction multiplication problems. The thinking behind having students draw the pictures is supposedly to "drill" the understanding of what is happening with fraction multiplication, before they are then allowed to do it by the algorithmic method.

The approaches to math teaching in the lower grades in schools is a product of many years of mischaracterizing and maligning traditional teaching methods. The math reform movement touts many poster children of math education. Their views and philosophies are taken as faith by school administrations, school districts and many teachers – teachers who have been indoctrinated in schools of education that teach these methods.

Such topsy-turvy approaches to math education have been around for more than two decades, but the interpretation and implementation of Common Core have made them more popular. To compensate for what reformers believe is a lack of understanding, the teaching of mathematics has been structured to drag work out far longer than necessary with multiple procedures, diagrams, and awkward, bulky explanations.

What ultimately happens is that these exercises in understanding simply become new procedures, which small children attempt to learn and memorize because that is what many small children do. On top of all that is that these methods are not efficient and very confusing, resulting in frustration and feeding into children's dislike of math—something this method was supposed to cure.

The Instructional "Shifts" of Common Core: The Source of Much of the Hidden Pedagogy

Where is this interpretation coming from? One possible source are the "shifts" in math instruction that are discussed on the website for Common Core. One of the shifts called for is "rigor" which the website translates as: "Pursue conceptual understanding,

procedural skills and fluency, and application with equal intensity". Further discussion at the website mentions that students should attain fluency with core functions such as multiplication (and by extension, multiplication of fractions): *"Students must be able to access concepts from a number of perspectives in order to see math as more than a set of mnemonics or discrete procedures."*

I learned of the connection between these "instructional shifts" talked about at the Common Core website, and the current practice of drilling understanding in a conversation I had with one of the key writers and designers of the EngageNY/Eureka Math program. (EngageNY started in New York State and is now being used in many school districts across the US.) On the EngageNY website, the "key shifts" in math instruction went from the three that were on the original Common Core website (Focus, Coherence and Rigor) to six. The last one of these six is called "dual intensity" is, according to my contact at EngageNY, an interpretation of Common Core's definition of "rigor" and states:

> "Dual Intensity: Students are practicing and understanding. There is more than a balance between these two things in the classroom – both are occurring with intensity. Teachers create opportunities for students to participate in "drills" and make use of those skills through extended application of math concepts. The amount of time and energy spent practicing and understanding learning environments is driven by the specific mathematical concept and therefore, varies throughout the given school year."

He told me that the original definition of rigor at the Common Core website was a stroke of genius that made it hard for anti-intellectuals to speak of "rigorous" in loosey-goosey ways. And, in fact he was able to justify the emphasis on fluency in the EngageNY/Eureka math curriculum. So while his intentions were good (using the definition of "rigor" to increase the emphasis on procedural fluency) it appears to me that he may have been unwittingly co-opted to make sure that "understanding" took precedence.

In our discussion, I pointed to EngageNY's insistence on students drawing diagrams to show place value in adding and subtracting numbers that required

regrouping (aka “carrying” and “borrowing”–words that are now anathema in this new age of math understanding). I asked if students were barred from using the standard algorithm until they acquired “mastery” of the pictorial procedure. His answer was evasive, along the lines of “Of course we want students to use numbers and not be dependent on diagrams, but it’s important that they understand how the algorithms work.” He eventually stated that Eureka “doesn’t do standard algorithms until students know the prerequisites needed to do them”.

Thus, despite Common Core’s proclamations that the standards do not prescribe pedagogical approaches, it would appear that in their definition of “rigor” they have left room for interpretations that understanding must come before procedure.

“Understanding” Coexists with Procedural Fluency

Understanding and procedure work in tandem. Sometimes understanding comes first, sometimes later. As evidenced by EngageNY/Eureka Math, and other programs making inroads in school districts across the US, the interpretations of Common Core have resulted in an “understanding first, procedure later” approach. That interpretation makes it appear as if both sides have reached common ground. Reformers can now say “You see? We’re not against drills”—provided such drills are drilling understanding.

The major problem with this approach is that not all students take away the understanding that the method is supposed to provide. Some get it, some don’t. And while it may work to give the adults who design such programs a mental visualization, they’ve had the advantage of many years of math experience (and brain growth) that students in 5th, 6th and even 7th and 8th grades do not have.

Students are forced to show what passes for understanding at every point of even the simplest computations. This drilling of understanding approach undermines what the reformers want to achieve in the first place. It is “rote understanding”: an out-loud articulation of meaning in every stage that is the arithmetic equivalent of forcing a reader to keep a finger on the page, sounding out every word, every time, with no progression of reading skill.

The Seductive Nature of a Bad Idea

The scary part about all of this is how easy it is to get swept in to the recommended methods. I was working with the fifth graders and insisting that they draw the diagram to go along with each problem, when midway through the period I realized that I was forcing them to do something that I felt was ineffective. The next day, I announced to them that instead of them having to do the rectangle diagrams, they could just do the fraction multiplication itself. While my decision was met by cheers from the fifth graders, I couldn't help feeling guilty in spite of my own beliefs. I imagined reformers shaking their heads in dismay, believing that I was leading the students down the path of ignorance, destined to be "math zombies".

The reform movement has succeeded in foisting its beliefs upon ever growing populations of new teachers who believe this is the only way. These beliefs are now extending to well-meaning mathematicians who had publicly opposed much of the reform philosophy. The math reform movement, in trying to overturn students "doing but not knowing" have unwittingly created a new poster child. While the reformers believe the new poster child represents one with "deep understanding", they have instead created a child for whom "understanding" foundational math is not even "doing" math.

About the author: Barry Garelick worked in the field of environmental protection; after retiring in 2011 he obtained a teaching credential in secondary mathematics. He now teaches math at a middle school in California. He has written articles on math education for The Atlantic, AMS Notices, Education Next, Education News, and Heartlander. He majored in mathematics at the University of Michigan. He has written three books about math education: "Letters from John Dewey/Letters from Huck Finn", "Confessions of a 21st Century Math Teacher", and "Math Education in the US: Still Crazy After All These Years."

MVP downgrades the teacher to "facilitator" and prevents traditional textbook use and lecture-style presentations where students take notes, and replaces it with placing kids in groups and having group members teach each other. Teachers do not like it and there is ample documentation showing that. There are many studies showing that the traditional lecture/notes style produces superior results in math. Group work is fine on a limited basis, but it should not be the basis of an entire curriculum. Kids need ample time to work independently. Below are a few research articles on these topics: Harvard Study Shows Lecture Style Presentations Lead to Higher Achievement and Why Minimal Guidance During Instruction Does Not Work.

By Education Next 04/19/2019

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Harvard Study Shows that Lecture-Style Presentations Lead to Higher Student Achievement

Widely-used problem-solving pedagogy as implemented in practice is not as effective for raising achievement levels

Cambridge, MA – A new study finds that 8th grade students in the U.S. score higher on standardized tests in math and science when their teachers allocate greater amounts of class time to lecture-style presentations than to group problem-solving activities. For both math and science, the study finds that a shift of 10 percentage points of time from problem solving to lecture-style presentations (for example, increasing the share of time spent lecturing from 60 to 70 percent) is associated with a rise in student test scores of 4 percent of a standard deviation for the students who had the exact same peers in both their math and science classes – or between one and two months' worth of learning in a typical school year.

These estimates are based on the actual implementation of teaching practices that the researchers observe in practice. Thus, while problem-solving activities may be very effective if implemented in the correct way, simply inducing the average teacher employed today to shift time in class from lecture style presentations to problem solving, without concern for how this is implemented, contains little potential to increase student achievement. On the contrary, the study's results indicate that there might even be adverse effects on student learning.
Guido Schwerdt, a postdoctoral fellow in Harvard's Program on Education Policy and Governance, and Amelie C. Wuppermann, a postdoctoral researcher at the University of Mainz, Germany, conducted the study. A research article, "Sage on the Stage," presenting the study's findings will

appear in the Summer 2011 issue of Education Next.

The researchers used data from the 2003 Trends in International Mathematics and Science Study (TIMSS). Their sample includes 6,310 students in 205 U.S. schools with 639 teachers (303 math teachers and 355 science teachers, of which 19 teacher both subjects). In addition to test scores in math and science, the TIMSS data include information on teacher characteristics, qualifications, and classroom practices. Most important for the analysis, teachers were asked what proportion of time in a typical week students spent on each of eight activities, and the authors' methodology focused on three of these activities — listening to lecture-style presentations, working on problems with the teacher's guidance, and working on problems without guidance — as a "good proxy for the time in class in which students are taught new material." They divide the amount of time spent listening to lecture-style presentations by the total amount of time spent on each of these three activities to generate a single measure of how much time the teacher devoted to lecturing relative to how much time was devoted to problem-solving activities.

Schwerdt and Wuppermann observe that in recent years, a consensus has emerged among researchers that teacher quality "matters enormously for student performance," but that relatively few rigorous studies have looked inside the classroom to see what kinds of teaching styles are the most effective. Their study of teaching styles finds that "teaching style matters for student achievement, but in the opposite direction than anticipated by conventional wisdom: an emphasis on lecture-style presentations (rather than problem-solving activities) is associated with an increase — not a decrease — in student achievement." They report that prominent organizations such as the National Research Council and the National Council of Teachers of Mathematics, for at least the last three decades, have "called for teachers to engage students in constructing their own new knowledge through more hands-on learning and group work." The emphasis on group problem-solving instructional methods has been incorporated into most U.S. teacher preparation programs, and the authors found that teachers in the study's sample allocated, on average, twice as much time to problem-solving activities as to lecturing, or "direct instruction."

The researchers recognize that a key challenge in studying the effects of teaching practices is that "teachers may adjust their methods in response to the ability or behavior of their students," perhaps relying more on lectures when assigned more capable or attentive students. To address these concerns, they "exploit the fact that the TIMSS study tested each student in both mathematics and science," which allowed them to compare the math and science test scores of individual students whose teacher in one subject tended to emphasize a different teaching style than their teacher in the other subject. They found that in both math and science, the positive relationship between lecture-style methods and test score gains was maintained. The estimated .04 standard deviation impact of a greater emphasis on lecturing is based on students who had the same peers in both classes, because that minimizes the chances that teaching styles — and their consequences — might differ depending on the composition of the class.

About the Authors:Guido Schwerdt is a postdoctoral fellow at the Program on Education Policy and Governance (PEPG) at Harvard University and a research at the Ifo Institute for Economic Research in Munich, Germany. Amelie C. Wuppermann is a postdoctoral researcher at the University of Mainz, Germany.

About Education Next : Education Next is a scholarly journal published by the Hoover Institution that is committed to looking at hard facts about school reform. Other sponsoring institutions are the Harvard Program on Education Policy and Governance, part of the Taubman Center for State and Local Government at the Harvard Kennedy School, and the Thomas B. Fordham Foundation.

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Educational Psychologist

ISSN: 0046-1520 (Print) 1532-6985 (Online) Journal homepage: https://www.tandfonline.com/loi/hedp20

Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching

Paul A. Kirschner , John Sweller & Richard E. Clark

To cite this article: Paul A. Kirschner , John Sweller & Richard E. Clark (2006) Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching, Educational Psychologist, 41:2, 75-86, DOI: 10.1207/s15326985ep4102_1

To link to this article: https://doi.org/10.1207/s15326985ep4102_1

EDUCATIONAL PSYCHOLOGIST, *41*(2), 75–86

Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching

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Evidence for the superiority of guided instruction is explained in the context of our knowledge of human cognitive architecture, expert–novice differences, and cognitive load. Although unguided or minimally guided instructional approaches are very popular and intuitively appealing, the point is made that these approaches ignore both the structures that constitute human cognitive architecture and evidence from empirical studies over the past half-century that consistently indicate that minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process. The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge to provide "internal" guidance. Recent developments in instructional research and instructional design models that support guidance during instruction are briefly described.

Disputes about the impact of instructional guidance during teaching have been ongoing for at least the past half-century (Ausubel, 1964; Craig, 1956; Mayer, 2004; Shulman & Keisler, 1966). On one side of this argument are those advocating the hypothesis that people learn best in an unguided or minimally guided environment, generally defined as one in which learners, rather than being presented with essential information, must discover or construct essential information for themselves (e.g., Bruner, 1961; Papert, 1980; Steffe & Gale, 1995). On the other side are those suggesting that novice learners should be provided with direct instructional guidance on the concepts and procedures required by a particular discipline and should not be left to discover those procedures by themselves (e.g., Cronbach & Snow, 1977; Klahr & Nigam, 2004; Mayer, 2004; Shulman & Keisler, 1966; Sweller, 2003). Direct instructional guidance is defined as providing information that fully explains the concepts and procedures that students are required to learn as well as learning strategy support that is compatible with human cognitive architecture. Learning, in turn, is defined as a change in long-term memory.

The minimally guided approach has been called by various names including discovery learning (Anthony, 1973; Bruner, 1961); problem-based learning (PBL; Barrows & Tamblyn, 1980; Schmidt, 1983), inquiry learning (Papert, 1980; Rutherford, 1964), experiential learning (Boud, Keogh, & Walker, 1985; Kolb & Fry, 1975), and constructivist learning (Jonassen, 1991; Steffe & Gale, 1995). Examples of applications of these differently named but essentially pedagogically equivalent approaches include

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science instruction in which students are placed in inquiry learning contexts and asked to discover the fundamental and well-known principles of science by modeling the investigatory activities of professional researchers (Van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005). Similarly, medical students in problem-based teaching courses are required to discover medical solutions for common patient problems using problem-solving techniques (Schmidt, 1998, 2000).

There seem to be two main assumptions underlying instructional programs using minimal guidance. First they challenge students to solve "authentic" problems or acquire complex knowledge in information-rich settings based on the assumption that having learners construct their own solutions leads to the most effective learning experience. Second, they appear to assume that knowledge can best be acquired through experience based on the procedures of the discipline (i.e., seeing the pedagogic content of the learning experience as identical to the methods and processes or epistemology of the discipline being studied; Kirschner, 1992). Minimal guidance is offered in the form of process- or task-relevant information that is available if learners choose to use it. Advocates of this approach imply that instructional guidance that provides or embeds learning strategies in instruction interferes with the natural processes by which learners draw on their unique prior experience and learning styles to construct new situated knowledge that will achieve their goals. According to Wickens (1992, cited in Bernstein, Penner, Clarke-Stewart, Roy, & Wickens, 2003), for example,

> large amounts of guidance may produce very good performance during practice, but too much guidance may impair later performance. Coaching students about correct responses in math, for example, may impair their ability later to retrieve correct responses from memory on their own. (p. 221)

This constructivist argument has attracted a significant following.

The goal of this article is to suggest that based on our current knowledge of human cognitive architecture, minimally guided instruction is likely to be ineffective. The past half-century of empirical research on this issue has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning.

THE CONSEQUENCES OF HUMAN COGNITIVE ARCHITECTURE FOR MINIMAL GUIDANCE DURING INSTRUCTION

Any instructional procedure that ignores the structures that constitute human cognitive architecture is not likely to be effective. Minimally guided instruction appears to proceed

with no reference to the characteristics of working memory, long-term memory, or the intricate relations between them. The result is a series of recommendations that most educators find almost impossible to implement—and many experienced educators are reluctant to implement—because they require learners to engage in cognitive activities that are highly unlikely to result in effective learning. As a consequence, the most effective teachers may either ignore the recommendations or, at best, pay lip service to them (e.g., Aulls, 2002). In this section we discuss some of the characteristics of human cognitive architecture and the consequent instructional implications.

Human Cognitive Architecture

Human cognitive architecture is concerned with the manner in which our cognitive structures are organized. Most modern treatments of human cognitive architecture use the Atkinson and Shiffrin (1968) sensory memory–working memory–long-term memory model as their base. Sensory memory is not relevant to the discussion here so it is not considered further. The relations between working and long-term memory, in conjunction with the cognitive processes that support learning, are of critical importance to the argument.

Our understanding of the role of long-term memory in human cognition has altered dramatically over the last few decades. It is no longer seen as a passive repository of discrete, isolated fragments of information that permit us to repeat what we have learned. Nor is it seen only as a component of human cognitive architecture that has merely peripheral influence on complex cognitive processes such as thinking and problem solving. Rather, long-term memory is now viewed as the central, dominant structure of human cognition. Everything we see, hear, and think about is critically dependent on and influenced by our long-term memory.

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De Groot's (1945/1965) work on chess expertise, followed by Chase and Simon (1973), has served as a major influence on the field's reconceptualization of the role of long-term memory. The finding that expert chess players are far better able than novices to reproduce briefly seen board configurations taken from real games, but do not differ in reproducing random board configurations, has been replicated in a variety of other areas (e.g., Egan & Schwartz, 1979; Jeffries, Turner, Polson, & Atwood, 1981; Sweller & Cooper, 1985). These results suggest that expert problem solvers derive their skill by drawing on the extensive experience stored in their long-term memory and then quickly select and apply the best procedures for solving problems. The fact that these differences can be used to fully explain problem-solving skill emphasizes the importance of long-term memory to cognition. We are skillful in an area because our long-term memory contains huge amounts of information concerning the area. That information permits us to quickly recognize the characteristics of a situation and indicates to us, often unconsciously, what to do and when to do it. Without our huge store of information in long-term memory,

we would be largely incapable of everything from simple acts such as crossing a street (information in long-term memory informs us how to avoid speeding traffic, a skill many other animals are unable to store in their long-term memories) to complex activities such as playing chess or solving mathematical problems. Thus, our long-term memory incorporates a massive knowledge base that is central to all of our cognitively based activities.

What are the instructional consequences of long-term memory? In the first instance and at its most basic, the architecture of long-term memory provides us with the ultimate justification for instruction. The aim of all instruction is to alter long-term memory. If nothing has changed in long-term memory, nothing has been learned. Any instructional recommendation that does not or cannot specify what has been changed in long-term memory, or that does not increase the efficiency with which relevant information is stored in or retrieved from long-term memory, is likely to be ineffective.

Working Memory Characteristics and Functions

Working memory is the cognitive structure in which conscious processing occurs. We are only conscious of the information currently being processed in working memory and are more or less oblivious to the far larger amount of information stored in long-term memory.

Working memory has two well-known characteristics: When processing novel information, it is very limited in duration and in capacity. We have known at least since Peterson and Peterson (1959) that almost all information stored in working memory and not rehearsed is lost within 30 sec and have known at least since Miller (1956) that the capacity of working memory is limited to only a very small number of elements. That number is about seven according to Miller, but may be as low as four, plus or minus one (see, e.g., Cowan,

ements. That number is about seven according to Miller, but may be as low as four, plus or minus one (see, e.g., Cowan, 2001). Furthermore, when processing rather than merely storing information, it may be reasonable to conjecture that the number of items that can be processed may only be two or three, depending on the nature of the processing required.

The interactions between working memory and long-term memory may be even more important than the processing limitations (Sweller, 2003, 2004). The limitations of working memory only apply to new, yet to be learned information that has not been stored in long-term memory. New information such as new combinations of numbers or letters can only be stored for brief periods with severe limitations on the amount of such information that can be dealt with. In contrast, when dealing with previously learned information stored in long-term memory, these limitations disappear. In the sense that information can be brought back from long-term memory to working memory over indefinite periods of time, the temporal limits of working memory become irrelevant. Similarly, there are no known limits to the amount of such information that can be brought into working memory from long-term memory. Indeed, the altered characteristics of

working memory when processing familiar as opposed to unfamiliar material induced Ericsson and Kintsch (1995) to propose a separate structure, long-term working memory, to deal with well-learned and automated information.

Any instructional theory that ignores the limits of working memory when dealing with novel information or ignores the disappearance of those limits when dealing with familiar information is unlikely to be effective. Recommendations advocating minimal guidance during instruction proceed as though working memory does not exist or, if it does exist, that it has no relevant limitations when dealing with novel information, the very information of interest to constructivist teaching procedures. We know that problem solving, which is central to one instructional procedure advocating minimal guidance, called inquiry-based instruction, places a huge burden on working memory (Sweller, 1988). The onus should surely be on those who support inquiry-based instruction to explain how such a procedure circumvents the well-known limits of working memory when dealing with novel information.

Implications of Human Cognitive Architecture for Constructivist Instruction

These memory structures and their relations have direct implications for instructional design (e.g., Sweller, 1999; Sweller, van Merriënboer & Paas, 1998). Inquiry-based instruction requires the learner to search a problem space for problem-relevant information. All problem-based searching makes heavy demands on working memory. Furthermore,

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These memory structures and their relations have direct implications for instructional design (e.g., Sweller, 1999; Sweller, van Merriënboer & Paas, 1998). Inquiry-based instruction requires the learner to search a problem space for problem-relevant information. All problem-based searching makes heavy demands on working memory. Furthermore, that working memory load does not contribute to the accumulation of knowledge in long-term memory because while working memory is being used to search for problem solutions, it is not available and cannot be used to learn. Indeed, it is possible to search for extended periods of time with quite minimal alterations to long-term memory (e.g., see Sweller, Mawer, & Howe, 1982). The goal of instruction is rarely simply to search for or discover information. The goal is to give learners specific guidance about how to cognitively manipulate information in ways that are consistent with a learning goal, and store the result in long-term memory.

The consequences of requiring novice learners to search for problem solutions using a limited working memory or the mechanisms by which unguided or minimally guided instruction might facilitate change in long-term memory appear to be routinely ignored. The result is a set of differently named but similar instructional approaches requiring minimal guidance that are disconnected from much that we know of human cognition. Recommending minimal guidance was understandable when Bruner (1961) proposed discovery learning as an instructional tool because the structures and relations that constitute human cognitive architecture had not yet been mapped. We now are in a quite different environment because we know much more about the structures, functions, and characteristics of working and long-term memory; the relations between them; and their consequences

for learning and problem solving. This new understanding has been the basis for systematic research and development of instructional theories that reflect our current understanding of cognitive architecture (e.g., Anderson, 1996; Glaser, 1987). This work should be central to the design of effective, guided instruction.

Of course, suggestions based on theory that minimally guided instruction should have minimal effectiveness are worth little without empirical evidence. Empirical work comparing guided and unguided instruction is discussed after a review of the current arguments for minimal guidance.

THE ORIGINS OF CONSTRUCTIVISM AND THE CURRENT VIEW OF MINIMALLY GUIDED INSTRUCTION

Given the incompatibility of minimally guided instruction with our knowledge of human cognitive architecture, what has been the justification for these approaches? The most recent version of instruction with minimal guidance comes from constructivism (e.g., Steffe & Gale, 1995), which appears to have been derived from observations that knowledge is constructed by learners and so (a) they need to have the opportunity to construct by being presented with goals and minimal information, and (b) learning is idiosyncratic and so a common instructional format or strategies are ineffective. The constructivist description of learning is accurate, but the instructional consequences suggested by constructivists do not necessarily follow.

through experience that is based primarily on the procedures of the discipline. This point of view led to a commitment by educators to extensive practical or project work, and the rejection of instruction based on the facts, laws, principles and theories that make up a discipline's content accompanied by the use of discovery and inquiry methods of instruction. The addition of a more vigorous emphasis on the practical application of inquiry and problem-solving skills seems very positive. Yet it may be a fundamental error to assume that the pedagogic content of the learning experience is identical to the methods and processes (i.e., the epistemology) of the discipline being studied and a mistake to assume that instruction should exclusively focus on methods and processes.

Shulman (1986; Shulman & Hutchings, 1999) contributed to our understanding of the reason why less guided approaches fail in his discussion of the integration of content expertise and pedagogical skill. He defined *content knowledge* as "the amount and organization of the knowledge per se in the mind of the teacher" (Shulman, 1986, p. 9), and *pedagogical content knowledge* as knowledge "which goes beyond knowledge of subject matter per se to the dimension of subject knowledge for teaching" (p. 9). He further defined *curricular knowledge* as "the pharmacopoeia from which the teacher draws those tools of teaching that present or exemplify particular content" (p. 10). Kirschner (1991, 1992) also argued that the way an expert works in his or her domain (epistemology) is not equivalent to the way one learns in that area (pedagogy). A similar line of reasoning was followed by Dehoney (1995), who posited that the mental models and strategies of experts have been developed through the slow

from constructivism (e.g., Steffe & Gale, 1995), which appears to have been derived from observations that knowledge is constructed by learners and so (a) they need to have the opportunity to construct by being presented with goals and minimal information, and (b) learning is idiosyncratic and so a common instructional format or strategies are ineffective. The constructivist description of learning is accurate, but the instructional consequences suggested by constructivists do not necessarily follow.

Most learners of all ages know how to construct knowledge when given adequate information and there is no evidence that presenting them with partial information enhances their ability to construct a representation more than giving them full information. Actually, quite the reverse seems most often to be true. Learners must construct a mental representation or schema irrespective of whether they are given complete or partial information. Complete information will result in a more accurate representation that is also more easily acquired. Constructivism is based therefore, on an observation that, although descriptively accurate, does not lead to a prescriptive instructional design theory or to effective pedagogical techniques (Clark & Estes, 1998, 1999; Estes & Clark, 1999; Kirschner, Martens, & Strijbos, 2004). Yet many educators, educational researchers, instructional designers, and learning materials developers appear to have embraced minimally guided instruction and tried to implement it.

Another consequence of attempts to implement constructivist theory is a shift of emphasis away from teaching a discipline as a body of knowledge toward an exclusive emphasis on learning a discipline by experiencing the processes and procedures of the discipline (Handelsman et. al., 2004; Hodson, 1988). This change in focus was accompanied by an assumption shared by many leading educators and discipline specialists that knowledge can best be learned or only learned subject knowledge for teaching" (p. 9). He further defined *curricular knowledge* as "the pharmacopoeia from which the teacher draws those tools of teaching that present or exemplify particular content" (p. 10). Kirschner (1991, 1992) also argued that the way an expert works in his or her domain (epistemology) is not equivalent to the way one learns in that area (pedagogy). A similar line of reasoning was followed by Dehoney (1995), who posited that the mental models and strategies of experts have been developed through the slow process of accumulating experience in their domain areas.

Despite this clear distinction between learning a discipline and practicing a discipline, many curriculum developers, educational technologists, and educators seem to confuse the teaching of a discipline as inquiry (i.e., a curricular emphasis on the research processes within a science) with the teaching of the discipline by inquiry (i.e., using the research process of the discipline as a pedagogy or for learning). The basis of this confusion may lie in what Hurd (1969) called the rationale of the scientist, which holds that a course of instruction in science

> should be a mirror image of a science discipline, with regard to both its conceptual structure and its patterns of inquiry. The theories and methods of modern science should be reflected in the classroom. In teaching a science, classroom operations should be in harmony with its investigatory processes and supportive of the conceptual, the intuitive, and the theoretical structure of its knowledge. (p. 16)

This rationale assumes

> that the attainment of certain attitudes, the fostering of interest in science, the acquisition of laboratory skills, the learning of scientific knowledge, and the understanding of the nature of science were all to be approached through the

> methodology of science, which was, in general, seen in inductive terms. (Hodson, 1988, p. 22)

The major fallacy of this rationale is that it makes no distinction between the behaviors and methods of a researcher who is an expert practicing a profession and those students who are new to the discipline and who are, thus, essentially novices.

According to Kyle (1980), scientific inquiry is a systematic and investigative performance ability incorporating unrestrained thinking capabilities after a person has acquired a broad, critical knowledge of the particular subject matter through formal teaching processes. It may not be equated with investigative methods of science teaching, self-instructional teaching techniques, or open-ended teaching techniques. Educators who confuse the two are guilty of the improper use of inquiry as a paradigm on which to base an instructional strategy.

Finally, Novak (1988), in noting that the major effort to improve secondary school science education in the 1950s and 1960s fell short of expectations, went so far as to say that the major obstacle that stood in the way of "revolutionary improvement of science education … was the obsolete epistemology that was behind the emphasis on 'inquiry' oriented science" (pp. 79–80).

RESEARCH COMPARING GUIDED AND UNGUIDED INSTRUCTION

None of the preceding arguments and theorizing would be important if there was a clear body of research using controlled experiments indicating that unguided or minimally lem-based and inquiry learning, which now gives way to constructivist instructional techniques. Mayer (2004) concluded that the "debate about discovery has been replayed many times in education but each time, the evidence has favored a guided approach to learning" (p. 18).

Current Research Supporting Direct Guidance

Because students learn so little from a constructivist approach, most teachers who attempt to implement classroom-based constructivist instruction end up providing students with considerable guidance. This is a reasonable interpretation, for example, of qualitative case studies conducted by Aulls (2002), who observed a number of teachers as they implemented constructivist activities in their classrooms. He described the "scaffolding" that the most effective teachers introduced when students failed to make learning progress in a discovery setting. He reported that the teacher whose students achieved all of their learning goals spent a great deal of time in instructional interactions with students by

> simultaneously teaching content and scaffolding-relevant procedures … by (a) modeling procedures for identifying and self-checking important information … (b) showing students how to reduce that information to paraphrases … (c) having students use notes to construct collaborations and routines, and (d) promoting collaborative dialogue within problems. (p. 533)

Stronger evidence from well-designed, controlled experimental studies also supports direct instructional guidance

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RESEARCH COMPARING GUIDED AND UNGUIDED INSTRUCTION

None of the preceding arguments and theorizing would be important if there was a clear body of research using controlled experiments indicating that unguided or minimally guided instruction was more effective than guided instruction. In fact, precisely as one might expect from our knowledge of human cognition and the distinctions between learning and practicing a discipline, the reverse is true. Controlled experiments almost uniformly indicate that when dealing with novel information, learners should be explicitly shown what to do and how to do it.

A number of reviews of empirical studies have established a solid research-based case against the use of instruction with minimal guidance. Although an extensive review of those studies is outside the scope of this article, Mayer (2004) recently reviewed evidence from studies conducted from 1950 to the late 1980s comparing pure discovery learning, defined as unguided, problem-based instruction, with guided forms of instruction. He suggested that in each decade since the mid-1950s, when empirical studies provided solid evidence that the then popular unguided approach did not work, a similar approach popped up under a different name with the cycle then repeating itself. Each new set of advocates for unguided approaches seemed either unaware of or uninterested in previous evidence that unguided approaches had not been validated. This pattern produced discovery learning, which gave way to experiential learning, which gave way to prob-

> procedures … by (a) modeling procedures for identifying and self-checking important information … (b) showing students how to reduce that information to paraphrases … (c) having students use notes to construct collaborations and routines, and (d) promoting collaborative dialogue within problems. (p. 533)

Stronger evidence from well-designed, controlled experimental studies also supports direct instructional guidance (e.g., see Moreno, 2004; Tuovinen & Sweller, 1999). Hardiman, Pollatsek, and Weil (1986) and Brown and Campione (1994) noted that when students learn science in classrooms with pure-discovery methods and minimal feedback, they often become lost and frustrated, and their confusion can lead to misconceptions. Others (e.g., Carlson, Lundy, & Schneider, 1992; Schauble, 1990) found that because false starts are common in such learning situations, unguided discovery is most often inefficient. Moreno (2004) concluded that there is a growing body of research showing that students learn more deeply from strongly guided learning than from discovery. Similar conclusions were reported by Chall (2000), McKeough, Lupart, and Marini (1995), Schauble (1990), and Singley and Anderson (1989). Klahr and Nigam (2004), in a very important study, not only tested whether science learners learned more via a discovery versus direct instruction route but also, once learning had occurred, whether the quality of learning differed. Specifically, they tested whether those who had learned through discovery were better able to transfer their learning to new contexts. The findings were unambiguous. Direct instruction involving considerable guidance, including examples, resulted in vastly more learning than discovery. Those relatively few

students who learned via discovery showed no signs of superior quality of learning.

Cognitive load. Sweller and others (Mayer, 2001; Paas, Renkl, & Sweller, 2003, 2004; Sweller, 1999, 2004; Winn, 2003) noted that despite the alleged advantages of unguided environments to help students to derive meaning from learning materials, cognitive load theory suggests that the free exploration of a highly complex environment may generate a heavy working memory load that is detrimental to learning. This suggestion is particularly important in the case of novice learners, who lack proper schemas to integrate the new information with their prior knowledge. Tuovinen and Sweller (1999) showed that exploration practice (a discovery technique) caused a much larger cognitive load and led to poorer learning than worked-examples practice. The more knowledgeable learners did not experience a negative effect and benefited equally from both types of treatments. Mayer (2001) described an extended series of experiments in multimedia instruction that he and his colleagues have designed drawing on Sweller's (1988, 1999) cognitive load theory and other cognitively based theoretical sources. In all of the many studies he reported, guided instruction not only produced more immediate recall of facts than unguided approaches, but also longer term transfer and problem-solving skills.

Worked examples. A worked example constitutes the epitome of strongly guided instruction, whereas discovering the solution to a problem in an information-rich environment similarly constitutes the epitome of minimally guided discovery learning. The worked-example effect, which is based on cognitive load theory, occurs when learners required to solve problems perform worse on subsequent test problems

using our limited working memory. Problem-solving search is an inefficient way of altering long-term memory because its function is to find a problem solution, not alter long-term memory. Indeed, problem-solving search can function perfectly with no learning whatsoever (Sweller, 1988). Thus, problem-solving search overburdens limited working memory and requires working memory resources to be used for activities that are unrelated to learning. As a consequence, learners can engage in problem-solving activities for extended periods and learn almost nothing (Sweller et al., 1982).

In contrast, studying a worked example both reduces working memory load because search is reduced or eliminated and directs attention (i.e., directs working memory resources) to learning the essential relations between problem-solving moves. Students learn to recognize which moves are required for particular problems, the basis for the acquisition of problem-solving schemas (Chi, Glaser, & Rees, 1982). When compared to students who have solved problems rather than studied worked examples, the consequence is the worked-example effect.

There are conditions under which the worked-example effect is not obtainable. First, it is not obtainable when the worked examples are themselves structured in a manner that imposes a heavy cognitive load. In other words, it is quite possible to structure worked examples in a manner that imposes as heavy a cognitive load as attempting to learn by discovering a problem solution (Tarmizi & Sweller, 1988; Ward & Sweller, 1990). Second, the worked-example effect first disappears and then reverses as the learners' expertise increases. Problem solving only becomes relatively effective when learners are sufficiently experienced so that studying a worked example is, for them, a redundant activity that increases working memory load compared to generating a

but also longer term transfer and problem-solving skills.

Worked examples. A worked example constitutes the epitome of strongly guided instruction, whereas discovering the solution to a problem in an information-rich environment similarly constitutes the epitome of minimally guided discovery learning. The worked-example effect, which is based on cognitive load theory, occurs when learners required to solve problems perform worse on subsequent test problems than learners who study the equivalent worked examples. Accordingly, the worked-example effect, which has been replicated a number of times, provides some of the strongest evidence for the superiority of directly guided instruction over minimal guidance. The fact that the effect relies on controlled experiments adds to its importance.

The worked-example effect was first demonstrated by Sweller and Cooper (1985) and Cooper and Sweller (1987), who found that algebra students learned more studying algebra worked examples than solving the equivalent problems. Since those early demonstrations of the effect, it has been replicated on numerous occasions using a large variety of learners studying an equally large variety of materials (Carroll, 1994; Miller, Lehman, & Koedinger, 1999; Paas, 1992; Paas & van Merriënboer, 1994; Pillay, 1994; Quilici & Mayer, 1996; Trafton & Reiser, 1993). For novices, studying worked examples seems invariably superior to discovering or constructing a solution to a problem.

Why does the worked-example effect occur? It can be explained by cognitive load theory, which is grounded in the human cognitive architecture discussed earlier. Solving a problem requires problem-solving search and search must occur

possible to structure worked examples in a manner that imposes as heavy a cognitive load as attempting to learn by discovering a problem solution (Tarmizi & Sweller, 1988; Ward & Sweller, 1990). Second, the worked-example effect first disappears and then reverses as the learners' expertise increases. Problem solving only becomes relatively effective when learners are sufficiently experienced so that studying a worked example is, for them, a redundant activity that increases working memory load compared to generating a known solution (Kalyuga, Chandler, Tuovinen, & Sweller, 2001). This phenomenon is an example of the expertise reversal effect (Kalyuga, Ayres, Chandler, & Sweller, 2003). It emphasizes the importance of providing novices in an area with extensive guidance because they do not have sufficient knowledge in long-term memory to prevent unproductive problem-solving search. That guidance can be relaxed only with increased expertise as knowledge in long-term memory can take over from external guidance.

Process worksheets. Another way of guiding instruction is the use of process worksheets (Van Merriënboer, 1997). Such worksheets provide a description of the phases one should go through when solving the problem as well as hints or rules of thumb that may help to successfully complete each phase. Students can consult the process worksheet while they are working on the learning tasks and they may use it to note intermediate results of the problem-solving process.

Nadolski, Kirschner, and van Merriënboer (2005), for example, studied the effects of process worksheets with law students and found that the availability of a process worksheet had positive effects on learning task performance,

indicated by a higher coherence and more accurate content of the legal case being developed. Learners receiving guidance through process worksheets outperformed learners left to discover the appropriate procedures themselves.

RESEARCH ON EDUCATIONAL MODELS FAVORING MINIMAL GUIDANCE DURING INSTRUCTION IN VARIOUS SETTINGS

Having discussed both the human cognitive architecture responsible for learning and current research supporting direct instruction through guidance, this section discusses a number of the alternative educational models that see and use minimal guidance as an approach to learning and instruction.

Experiential Learning at Work

Kolb (1971) and Kolb and Fry (1975) argued that the learning process often begins with a person carrying out a particular action and then seeing or discovering the effect of the action in this situation. The second step is to understand these effects in the particular instance so that if the same action was taken in the same circumstances it would be possible to anticipate what would follow from the action. Using this pattern, the third step would be to understand the general principle under which the particular instance falls. They also suggested a number of learning styles that they hypothesized would influence the way that students took advantage of experiential situations.

Attempts to validate experiential learning and learning styles (Kolb, 1971, 1984, 1999) appear not to have been completely successful. Iliff (1994), for example, reported in "a

Individual Differences in Learning From Instruction

Constructivist approaches to instruction are based, in part, on a concern that individual differences moderate the impact of instruction. This concern has been shared by a large body of aptitude–treatment interaction (ATI) studies that examine whether the effects of different instructional methods are influenced by student aptitudes and traits (e.g., Cronbach & Snow, 1977; Kyllonen & Lajoie, 2003; Snow, Corno, & Jackson, 1996). Much of this work provides a clear antecedent to the expertise reversal effect, discussed earlier, according to which instructional methods that are effective for novices become less effective as expertise increases.

Cronbach and Snow's (1977) review of ATI research described a number of replicated ordinal and disordinal interactions between various instructional methods and aptitudes. One of the most common ATI findings according to Kyllonen and Lajoie (2003) was "that strong treatments benefited less able learners and weaker treatments benefited more able learners" (p. 82). This conclusion anticipated the now recognized scaffolding effect.

In the instructional methods described by Cronbach and Snow (1977) strong treatments implied highly structured instructional presentations where explicit organization of information and learning support were provided. The weaker treatments were relatively unstructured and so provided much less learning support. The aptitude measures used in the research reviewed by Cronbach and Snow were varied but usually involved some measure of specific subject matter knowledge and measures of crystallized and fluid ability. Snow and Lohman (1984) encouraged research that attempts to understand the cognitive processes demanded by specific

ipate what would follow from the action. Using this pattern, the third step would be to understand the general principle under which the particular instance falls. They also suggested a number of learning styles that they hypothesized would influence the way that students took advantage of experiential situations.

Attempts to validate experiential learning and learning styles (Kolb, 1971, 1984, 1999) appear not to have been completely successful. Iliff (1994), for example, reported in "a meta-analysis of 101 quantitative LSI studies culled from 275 dissertations and 624 articles that were qualitative, theoretical, and quantitative studies of ELT and the Kolb Learning Style Inventory" (Kolb, Boyatzis, & Mainemelis, 2001, p. 20) correlations classified as low (< .5) and effect sizes that were weak (.2) to medium (.5). He concluded that the magnitude of these statistics is not sufficient to meet standards of predictive validity to support the use of the measures or the experiential methods for training at work. Similarly, Ruble and Stout (1993), citing a number of studies from 1980 through 1991, concluded that the Kolb Learning Style Inventory (KLSI-1976; Kolb, 1976) has low test–retest reliability, that there is little or no correlation between factors that should correlate with the classification of learning styles, and that it does not enjoy a general acceptance of its usefulness, particularly for research purposes.

Roblyer (1996) and Perkins (1991) examined evidence for minimally guided pedagogy in instructional design and instructional technology studies. Both researchers concluded that the available evidence does not support the use of minimal guidance and both suggested that some form of stronger guidance is necessary for both effective learning and transfer.

formation and learning support were provided. The weaker treatments were relatively unstructured and so provided much less learning support. The aptitude measures used in the research reviewed by Cronbach and Snow were varied but usually involved some measure of specific subject matter knowledge and measures of crystallized and fluid ability. Snow and Lohman (1984) encouraged research that attempts to understand the cognitive processes demanded by specific learning goals. They argued for a concern with describing the cognitive processes required to learn specific classes of tasks, how those processes are reflected in learner aptitudes, and how characteristics of instructional treatments might compensate for students with lower relevant aptitude by providing needed cognitive processes to help them achieve learning and transfer goals.

Knowing Less After Instruction

A related set of findings in the ATI research paradigm was described by Clark (1989). He reviewed approximately 70 ATI studies and described a number of experiments in which lower aptitude students who choose or were assigned to unguided, weaker instructional treatments receive significantly lower scores on posttests than on pretest measures. He argued that the failure to provide strong learning support for less experienced or less able students could actually produce a measurable loss of learning. The educational levels represented in the studies reviewed ranged from elementary classrooms to university and work settings and included a variety of types of problems and tasks. Even more distressing is the

evidence Clark (1982) presented that when learners are asked to select between a more or a less unguided version of the same course, less able learners who choose less guided approaches tend to like the experience even though they learn less from it. Higher aptitude students who chose highly structured approaches tended to like them but achieve at a lower level than with less structured versions but did not suffer by knowing less after than before instruction. Clark hypothesized that the most effective components of treatments help less experienced learners by providing task-specific learning strategies embedded in instructional presentations. These strategies require explicit, attention-driven effort on the part of learners and so tend not to be liked, even though they are helpful to learning. More able learners, he suggested, have acquired implicit, task-specific learning strategies that are more effective for them than those embedded in the structured versions of the course. Clark pointed to suggestive evidence that more able students who select the more guided versions of courses do so because they believe that they will achieve the required learning with a minimum of effort. Studies described by Woltz (2003) are a recent and positive example of ATI research that examines the cognitive processing required for learning tasks. He provided evidence that the same learner might benefit from stronger and weaker treatments depending on the type of learning and transfer outcome desired.

Empirical Evidence About Science Learning From Unguided Instruction

when students have prerequisite knowledge and undergo some prior structured experiences.

Medical Problem-Based Learning Research

All in all, a lack of clarity about the difference between learning a discipline and research in the discipline coupled with the priority afforded to unbiased observation in the best inductivist and empiricist tradition has led many educators to advocate a problem-based method as the way to teach a discipline (Allen, Barker, & Ramsden, 1986; Anthony, 1973; Barrows & Tamblyn, 1980; Obioma, 1986). Not only did PBL seem to mesh with ideas in, for example, the philosophy of science, but it also fit well with progressive learner-centered views emphasizing direct experience and individual inquiry. Cawthron and Rowell (1978) stated that it all seemed to fit. The logic of knowledge and the psychology of knowledge coalesced under the umbrella term *discovery*. Why, he asked, should educators look further than the traditional inductivist and empiricist explanation of the process?

In an attempt to rescue medical students from lectures and memory-based recall exams, approximately 60 medical schools in North America have adopted PBL in the past two decades. This variant of constructivist instruction with minimal guidance, introduced at the McMaster University School of Medicine in 1969, asks medical students to work in groups to diagnose and suggest treatment for common patient symptoms. PBL student groups are supervised by a clinical faculty member who is directed not to solve problems for the students but instead to offer alternatives and

in groups to diagnose and suggest treatment for common patient symptoms. PBL student groups are supervised by a clinical faculty member who is directed not to solve problems for the students but instead to offer alternatives and suggest sources of information.

Empirical Evidence About Science Learning From Unguided Instruction

The work of Klahr and Nigam (2004), discussed earlier, unambiguously demonstrated the advantages of direct instruction in science. There is a wealth of such evidence. A series of reviews by the U.S. National Academy of Sciences has recently described the results of experiments that provide evidence for the negative consequences of unguided science instruction at all age levels and across a variety of science and math content. McCray, DeHaan, and Schuck (2003) reviewed studies and practical experience in the education of college undergraduates in engineering, technology, science, and mathematics. Gollub, Berthanthal, Labov, and Curtis (2003) reviewed studies and experience teaching science and mathematics in high school. Kilpatrick, Swafford, and Findell (2001) reported studies and made suggestions for elementary and middle school teaching of mathematics. Each of these and other publications by the U.S. National Academy of Sciences amply document the lack of evidence for unguided approaches and the benefits of more strongly guided instruction. Most provide a set of instructional principles for educators that are based on solid research. These reports were prepared, in part, because of the poor state of science and mathematics education in the United States. Finally, in accord with the ATI findings and the expertise reversal effect, Roblyer, Edwards, and Havriluk (1997) reported that teachers have found that discovery learning is successful only

The best known survey of the comparisons of PBL with conventional medical school instruction was conducted by Albanese and Mitchell (1993). Their meta-analysis of the English language literature of the effectiveness of PBL produced a number of negative findings concerning its impact, including lower basic science exam scores, no differences in residency selections, and more study hours each day. They reported that although PBL students receive better scores for their clinical performance, they also order significantly more unnecessary tests at a much higher cost per patient with less benefit. There was an indication in their review that increased clinical practice evaluation scores may have been due to the fact the PBL students are required to spend more time in clinical settings.

Berkson (1993) also reviewed much of the literature on PBL and arrived at many of the same conclusions as Albanese and Mitchell (1993). She reviewed studies where the problem-solving ability of PBL students was compared with the same ability in conventionally trained students and found no support for any differences, and so failed to replicate the clinical advantage found by Albanese and Mitchell. Colliver (2000) reviewed existing studies comparing the effectiveness of PBL in medicine to conventional medical school curricula. He concluded that PBL studies show no statistical effect on the

performance of medical students on standardized tests or on instructor-designed tests during the first 2 years of medical school. Also important for medical educators has been the constant finding in research summaries that PBL is not more effective but is more costly than traditional instruction. Of course, some supporters of PBL are aware of its limitations. Hmelo-Silver (2004) placed strong question marks concerning the general validity of PBL. According to her,

> Certain aspects of the PBL model should be tailored to the developmental level of the learners … there may be a place for direct instruction on a just-in-time basis. In other words, as students are grappling with a problem and confronted with the need for particular kinds of knowledge, a lecture at the right time may be beneficial. … Some techniques such as procedural facilitation, scripted cooperation, and structured journals may prove useful tools in moving PBL to other settings. (pp. 260–261)

Two major components of PBL are the explicit teaching of problem-solving strategies in the form of the hypothetico-deductive method of reasoning (Barrows & Tamblyn, 1980), and teaching of basic content in the context of a specific case or instance. Proponents argue that problem-centered education is superior to conventional education. Students taught problem-solving skills, in particular through the use of the hypothetico-deductive method, and given problems to practice those skills learn in a more meaningful way. It is assumed that because students are exposed to problems from the beginning of their training, they are better prepared to handle ... the organization of clinical and biomedical knowledge and the use of reasoning strategies, Arocha and Patel (1995) found that participants trained in PBL retained the backward-directed reasoning pattern, but did not seem to acquire forward-directed reasoning, which is a hallmark of expertise. This finding means that something in PBL may hinder the development of the forward reasoning pattern.

Experts use schema-based pattern recognition to determine the cause of a patient's illness. According to Elstein (1994) knowledge organization and schema acquisition are more important for the development of expertise than the use of particular methods of problem solving. In this regard, cognitive research has shown that to achieve expertise in a domain, learners must acquire the necessary schemata that allow them to meaningfully and efficiently interpret information and identify the problem structure. Schemata accomplish this by guiding the selection of relevant information and the screening out of irrelevant information.

Arocha and Patel (1995) concluded that the negative results

> can be accounted for by the effect of splitting of attention resources and the high working memory load on schema acquisition during problem solving. In solving clinical problems, subjects must attend to the current diagnostic hypothesis, the data in the problem presented to them, and any intermediate hypothesis between the diagnosis and the patient data (e.g., a pathophysiological process underlying the signs and symptoms). If we consider that more than one hypothesis has been generated, the cognitive resources needed for maintaining this information in working memory must

tion is superior to conventional education. Students taught problem-solving skills, in particular through the use of the hypothetico-deductive method, and given problems to practice those skills learn in a more meaningful way. It is assumed that because students are exposed to problems from the beginning, they have more opportunity to practice these skills, and that by explicitly applying the hypothetico-deductive method they learn to analyze problems and search for explanations, improving their comprehension of clinical problems (Norman & Schmidt, 1992). Patel and colleagues argued that the hypothetico-deductive method may not be the most efficient way of solving clinical problems (Patel & Groen, 1986; Patel, Arocha, & Kaufman, 1994).

In the medical domain, Patel, Groen, and Norman (1993) showed that teaching basic science within a clinical context may have the disadvantage that once basic science knowledge is contextualized, it is difficult to separate it from the particular clinical problems into which it has been integrated. They showed that students trained in a PBL curriculum failed to separate basic science knowledge from the specific clinical knowledge associated with particular patients. Although PBL students generated more elaborate explanations, they had less coherent explanations and more errors. If students have difficulty separating the biomedical knowledge they have learned from the particular clinical cases associated with that knowledge, it is not surprising that when given a different problem they bring to bear on the new problem some irrelevant biomedical knowledge.

This appears to persist after training. In a study of the effect of undergraduate training in PBL—as opposed to a conventional curriculum—on the performance of residents on

> pothesis, the data in the problem presented to them, and any intermediate hypothesis between the diagnosis and the patient data (e.g., a pathophysiological process underlying the signs and symptoms). If we consider that more than one hypothesis has been generated, the cognitive resources needed for maintaining this information in working memory must be such that few cognitive resources are left for acquiring the problem schema. Although problems can be solved successfully using the hypothetico-deductive method, the scarcity of attentional and memory resources may result in the students having difficulties learning problem schemata in an adequate manner. It is possible to hypothesize that one of the reasons for the failure of PBLC subjects to acquire a forward-directed reasoning style as found in this study may be the use of problem solving strategies, such as the hypothetico-deductive method, as a learning strategy.

This is completely in line with our claim that the epistemology of a discipline should not be confused with a pedagogy for teaching or learning it. The practice of a profession is not the same as learning to practice the profession.

CONCLUSIONS

After a half-century of advocacy associated with instruction using minimal guidance, it appears that there is no body of research supporting the technique. In so far as there is any evidence from controlled studies, it almost uniformly supports direct, strong instructional guidance rather than constructivist-based minimal guidance during the instruction of novice to intermediate learners. Even for students

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with considerable prior knowledge, strong guidance while learning is most often found to be equally effective as unguided approaches. Not only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge.

Although the reasons for the ongoing popularity of a failed approach are unclear, the origins of the support for instruction with minimal guidance in science education and medical education might be found in the post-*Sputnik* science curriculum reforms such as Biological Sciences Curriculum Study, Chemical Education Material Study, and Physical Science Study Committee. At that time, educators shifted away from teaching a discipline as a body of knowledge toward the assumption that knowledge can best or only be learned through experience that is based only on the procedures of the discipline. This point of view appears to have led to unguided practical or project work and the rejection of instruction based on the facts, laws, principles, and theories that make up a discipline's content. The emphasis on the practical application of what is being learned seems very positive. However, it may be an error to assume that the pedagogic content of the learning experience is identical to the methods and processes (i.e., the epistemology) of the discipline being studied and a mistake to assume that instruction should exclusively focus on application. It is regrettable that current constructivist views have become ideological and often epistemologically opposed to the presentation and explanation of knowledge. As a result, it is easy to share the puzzlement of Handelsman et al. (2004), who, when discussing science education, asked: "Why do outstanding scientists who demand rigorous proof for scientific assertions in their

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Wake MVP Parent

A blog from a parent's point of view about MVP math in Wake County, NC.

Thursday, May 23, 2019
MVP Ground-Zero Math Performance Data Exposed, and it Ain't Pretty: An Analysis of American Fork Junior & Senior High Math Trends

Note: Skip ahead to "Background" if you want to jump to the data

What if I told you I had a car to sell you - NO, GIVE YOU - that will bring you an increased feeling of #equity to all your driving needs!? In fact, you will gain "deeper driving" experiences which enable 21st century transportation skills like you've never seen before! No more "rote driving!" We're talking "real world" "critical driving" improvements. In fact, this new car satisfies all 8 practices of sound driving as identified by the National Council of Car Drivers - get this - by focusing only on ONE of them: Practice #8 - Use the steering wheel. You heard me right. By focusing on using the steering wheel the way that I'm going to teach you, you are going to be driving like never before! I'm willing to GIVE you this car - TODAY - if you are ready to engage in this really popular type of driving discourse. Soon enough, you'll be driving on DIS-course AND DAT-course! Get it? DIS-course? There's only one catch. You have to pay ME to teach YOU how to use that steering wheel MY WAY. And that is the ONLY way you can use it. Otherwise, Hey, fuggedabout it.

You say, "All those benefits sound great, but will it help my gas mileage? I'm getting 58 MPG now, which is pretty good. And that is my main priority when it comes to transportation!"

Is that all you think about? Measuring results? You're using traditional driving thinking. I assure you, speaking as an expert in this new drivagogy, you will be delighted in this new "discovery" method of driving the new way. (Drivagogy is "the method and practice of driving, especially as an academic subject or theoretical concept.")

Let me tell you, since I have been using my new drivagogy method, my MPG improved from 58 to 57.6 in less than 5 years!

"But wait. That's not an improvement. That is basically flat - actually a slight decline," you say.

You got to understand. The drive performance improvements don't come right away. You have to be patient. After a little productive struggle, you'll get the hang of it. Here - let me offer you this tasty beverage. Oh Yeaaaaah. Here at M.V.P. Motors, you have to taste this to believe it.

So, what would you do? I'm guessing that most sane people would drive, walk or RUN away from such a proposition. Unfortunately, that little story is closer to the truth than fiction.

Background

Mathematics Vision Project, LLC, was founded in 2013 by principal Travis Lemon. In addition to being the thought leader behind MVP, Mr. Lemon currently teaches at American Fork Junior High in American Fork, Utah, where he has taught since 2000. According to Karen Feld, who is also a math teacher at AFJHS, "Travis is an amazing mathematics educator who is focused on the learning and success of all students." Additionally. Ms. Feld notes, "My team and I use the MVP materials. These materials are excellent. The MVP materials allow students the opportunity to engage in the 8 Mathematical Practices and allow me the opportunity to include the high leverage and research based Effective Teaching Practices (NCTM, 2014) in my classroom. We have had great success and our students demonstrate high levels of mathematical understanding."

While I don't question Mr. Lemon or Ms. Feld in their passions for being teachers, I have a responsibility to look at the data in light of what we are seeing in Wake County. My thinking is this: American Fork Junior High School has CLEAR ADVANTAGES OVER EVERY OTHER SCHOOL OR SYSTEM ADOPTING MVP.

Expertise: As the creator, author, and #1 user of MVP, Mr. Lemon is arguably THE WORLDWIDE EXPERT on the subject.

Buy-In: Additionally, not only is he one of the MVP teachers at the school, he apparently has an adoring set of peers who wholeheartedly embrace the MVP curriculum.

On Demand Help: Furthermore, if there were ever any questions or issues to work through, Mr. Lemon could provide on-demand professional development in the Teachers' Lounge or cafeteria with his peers.

Certainly, for these 3 reasons, this is a PERFECT SCENARIO in which to deploy MVP and observe the mathematics comprehension bliss it will deliver to students! I think that most logical people would expect his school to produce the BEST RESULTS POSSIBLE compared to any other in the world.

Disclaimer

I have great respect for all teachers who give their all each and every day for their students. I know that no curriculum is perfect and no measurement system is perfect. Sometimes we may disagree about how and why things should be done in the field of "educating the children." Any observations or critiques I make below are not intended to be aimed at teachers or students, but to the decisions that perhaps should be reconsidered in hindsight.

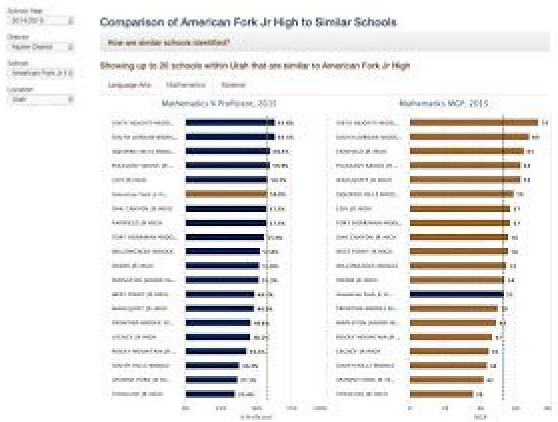
Utah's Data Gateway

The Utah State Board of Education provides a data gateway for citizens to examine school results. You can run a report for a school and you will see the school's results in context of up to 19 other schools that are similar. This "similarity comparison" is very insightful because it groups schools using a "general coefficient of similarity," taking into account about 11 variables contextualizing school attributes and student demographics.

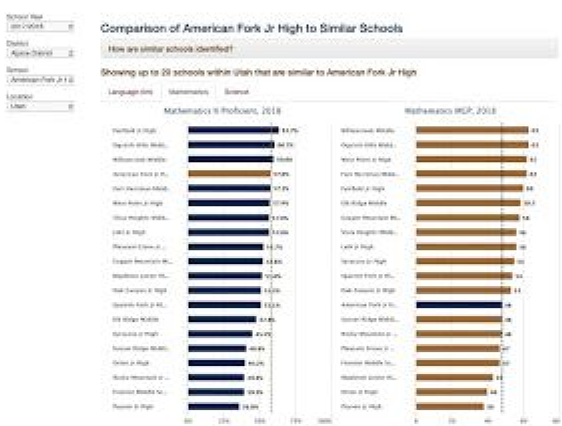
Utah measures % Proficient (percent of students who are grade proficient in a subject) and Median Growth Percentile (MGP). There is a video which explains MGP, but I will summarize. Student Growth Percentile (SGP) measures each individual student's percentile compared to similar performers in the prior year. MGP, however, measures how much students are improving from year to year as a group. An MGP of 55 would mean that for the population considered, the median SGP was 55. This would mean that the median SGP student improved better than 55% of his/her peers at the state level. In short, MGP measures year to year improvement. Utah's objective is that an SGP of 40 or higher is considered to have made sufficient growth.

2014/15 to 2017/18 Data

So let's look at the 2014-15 data for American Fork Junior High School. Here you will see the Proficiency is 58% meaning 58% of students were grade level proficient in math. The MGP measuring growth from the prior year was 53. Meaning that when we take all the AFJHS students and sort their SGPs, the median one was 53.



If we fast forward to 2017-18, let's see those results. You will note that there is not much change in proficiency from 2014-15 to 2017-18. However, the MGP declined from 53 to 48. Still OK, but declining.

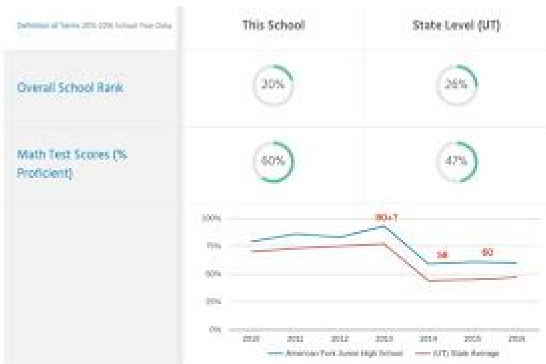


Pulling in the two years in between, the 4 year trend in proficiency is: 58 - 60 - 56.4 - 57.6
The 4 year trend in MGP is: 53 - 52 - 48 - 48.

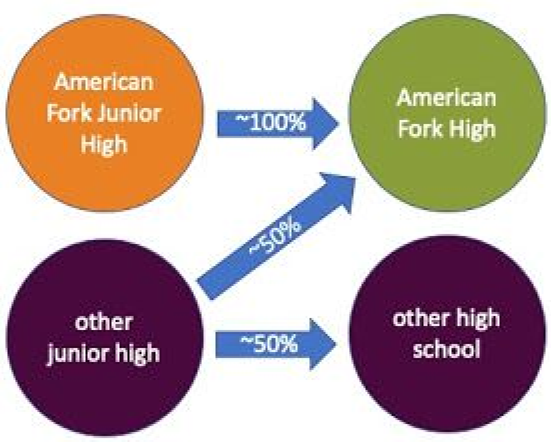
Pre 2014 Data

Now, when I saw this, I had some concerns. I am estimating that AFJHS started using MVP around 2013. After all, I would have expected Mr. Lemon to have a product nearly in hand before forming the Mathematics Vision Project, LLC. Anyway, the other thing that happened in the 2012-2013 timeframe is "common core". The data above doesn't go back before 2014. However, there is another source which shows some older data. This particular view seems to only be current through 2015-16.

As seen in the graph below, before Common Core, proficiency was on the rise from ~77% or so in 2010 up to around ~90% in 2013. Then Common Core and/or MVP became the law of the land at AFJHS. Most data I've seen for other schools shows a decline in scores once Common Core came into play. So I will not focus so much on that because this report is not about Common Core. It's about MVP. And for all intents and purposes, it seems that the 4 years of data available at the original data gateway aligns to MVP years 2-5 at American Fork Junior High School.



Comparing & Contrast with Two Other Schools



To complete this analysis, I looked at two other schools. The first was American Fork High School. Approximately 100% of the students from AFJHS feed into the high school of the same name. Additionally, about 50% of students from another junior high feed into the same AFHS. This is illustrated as shown. My thinking was that the MVP students leaving the junior high could also be measured in high school. Even though we don't know the curriculum of the "other junior high school" about 2/3 of the math

students at American Fork High School are from AFJHS. So the data would be interesting if nothing else.

For the record, I reached out to teachers at the American Fork High School and asked if they used MVP. They were very nice and responded promptly. The answers included these comments:
We do not use MVP. If we do, we use it sporadically, maybe once or twice each term.

We use our own curriculum and some teachers choose to insert an MVP lesson or two into our curriculum where they see necessary but it is not common.

From my brief interactions with it, we as a department saw many issues with it and haven’t ever pushed for it at our school.
I personally use MVP very little. At the high school level, I find tasks are a great tool for discovering some concepts, supplementing others, and some just require old fashioned direct instruction.

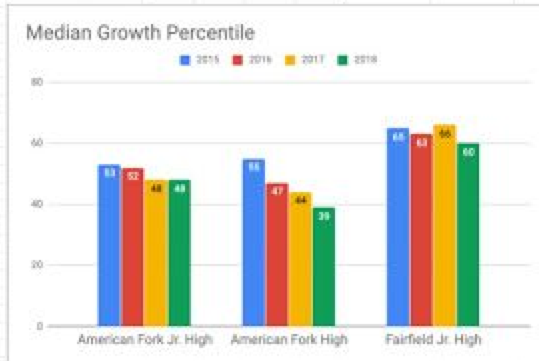
As a department at our high school, we are working to incorporate more tasks because most of us teachers use primarily direct instruction, and we feel that tasks could deepen understanding.

The second other school I looked at was Fairfield Junior High, which is in Kaysville, Utah, in the Davis County District. Why Fairfield? If you will refer back to the 2017-18 comparison graphic for AFJHS, you will see Fairfield at the top of the list. Again, Fairfield is a school which is similar to AFJHS. In fact, the website shows them as 91% similar. I wondered how they fared over the prior 4 years, so I pulled that data too.

Let's see the results. Let it soak in.

	% Proficient			
	2015	2016	2017	2018
American Fork Jr. High	58	60	56.4	57.6
American Fork High	53.8	47.3	42.5	36.4
Fairfield Jr. High	57.5	61.4	61	63.7

	MGP			
	2015	2016	2017	2018
American Fork Jr. High	53	52	48	48
American Fork High	55	47	44	39
Fairfield Jr. High	65	63	66	60



Observations

So here are some observations:
As noted above, you see that American Fork Junior High is relatively flat on Proficiency, and down on Growth (MGP).

But look at the high school (where 2/3 of its students are from AFJHS). Down... Down... Down... on both Proficiency and Growth. Just to be clear, we don't have a perfect correlation that says that MVP students at AFJHS are driving the declines at AFHS, but there seems to be some correlation based on the 2/3 of the high school students represented being from the MVP junior high. If I was a parent of those AFJHS or AFHS students, I would certainly want to know.

At the high school, Proficiency has dropped 17.4 points from 53.8 to 36.4. That is about a 1/3 drop and reflects devastating news to the students and parents affected.

One might be tempted to think that if the high school would only adopt MVP, then the MVP kids coming from the junior high school would do OK. But think about that logic. The direct teaching style is what students will experience in college. If they are not making the transition from junior high (discovery) to senior high (direct), then I shudder to think how they will handle math in college.

Growth at this high school is down 16 points from 55 to 39, another drop of nearly 1/3. The 39 is BELOW what Utah considers acceptable growth. Is anyone there looking at these results and wondering, "W. T. H?!!"

Now, we look at Fairfield. Their proficiency has steadily increased over this same period from 57.5 to 63.7 which is 6.2 points, or a 10.8% increase. Growth has dropped a tad from 65 to 60, but still the Growth results are outstanding and well over 50.

I'm not shy about reaching out to strangers, so I did. I contacted teachers at Fairfield Junior High and wanted to find out what their secret to success was! After all, isn't this one of the ways education leaders should select new ideas and curricula? Find out what works!

I met with Lori Kalt there, and here's what she told me:
A/B block schedule, so we see our students every-other day for 80-minute class periods.

We defied the recommendation and push from our district to use their adopted curriculum (Carnegie) and we developed our own curriculum. (By the way, if you compare Fairfield among all 26 junior high schools in their county - they are #2 in math proficiency for 2017-18. Lori noted that the #1 school, Kaysville Jr. High, does not use the block schedule for math - so their math class-time is considerably longer.)

We employ lots of best practices in our curriculum which includes lots of direct instruction, skill-based practice for fluency (on skill-based concepts), whole-class activities and dialogue to help students grasp and understand conceptual things, analyzing mistakes, fine-tuning understandings using mini white boards, and daily short quizzes on each standard.

We use standards based grading and students have multiple opportunities to show mastery on concepts - not unlimited opportunities but students can retake quizzes a few times

We make sure all students are fluent on foundation skills such as solving equations, constructing equations, graphing equations etc.

She also noted, we are currently receiving a LOT of pressure from our district to employ the use of tasks more frequently. I work with an amazing group of math teachers and we are all like-minded and collaborate a LOT with each other. We are hesitant to wholly

employ the latest fad(s) in education which right now seems to be tasks, discovery, project-based learning, and personalized/online learning.

Conclusion

So there you have it. Who would have thought that having human teachers create a curriculum from scratch could beat a bill of goods and services which has cost Wake County over $1.5M?

Who would have thought that teaching using a mixture of various crazy ideas such as:
direct instruction,
skill-based practice for fluency (on skill-based concepts),
whole-class activities and dialogue to help students grasp and understand conceptual things,
analyzing mistakes,
fine-tuning understandings using mini white boards, and
daily short quizzes on each standard
would have resulted in not only UP-TRENDING results, but clear leadership compared to similar schools?

Who would have thought that those results would be far superior to ground-zero of the latest and greatest trend in so-called innovative (yet-unproven) constructivist mathematics pedagogy?

I tell you who: ME... and many other parents and teachers in Wake County and around the US and Canada who know better than to risk our students' futures on a tweet filled with feel-good hashtags, or on a chance meeting at a dog and pony show at a math conference.

You know what WCPSS should do NOW that they know the truth about MVP?

https://wakemvp.blogspot.com/2019/05/w-t-h-mvp-ground-zero-math-performance.html?m=1

This is a list of some of the frequently asked questions from the MVP website. These are the words straight from Mathematics Vision Projects own admission.

- **The MVP curriculum was designed for Common Core Math Standards**

- **homework help is not provided.**
- **students and teachers will be required to search the internet for content material**
- **MVP should never be used by a teacher who is uncomfortable with the material**
- **MVP Units are supplemental tasks- Not a content based math foundation.**
- **No practice math problems will be provided by the company in this math curriculum.**

FAQ's from Mathematics Vision Project

https://www.mathematicsvisionproject.org/faqs.html

Q: Are the MVP Secondary Mathematics Textbook meant for everyone?
A: *The* MVP Secondary Mathematics Textbook *is available for any teacher teaching towards an integrated model of the* ***Common Core State Standards*** *to use free of charge. The book is designed around the* Comprehensive Mathematics Instruction (CMI) *model. Most of the tasks call for a sense-making and reasoning approach.* ***If this approach is unfamiliar to you or uncomfortable for you to implement, it might be best for you to use a different set of materials until you are better prepared.***

TRANSLATION:

- **It states clearly the curriculums intent to align to Common Core State Standards. North Carolina (according to All Central office employees) is not a Common Core math state since the adoption of the new "NC State Standards".**
- **The company states "it might be best for you to use a different set of materials until you are better prepared" before fully implementing MVP into the classroom. This implies that these materials are not meant to stand alone as a teaching tool for teachers.**

Q: How are these materials organized?
A: *You can find an overview of the structure of the materials here. The student book has the teaching tasks that are meant for the daily classroom experience. These teaching tasks are paired with a "READY, SET, GO" homework set of problems. The "READY, SET, GO" homework sets may be supported with the "Homework Help" materials taken from the ck12.org site.* **The "Homework Help" section is not always provided because there exist many such supports online and in widely used basal texts.**

TRANSLATION:

- **MVP CLEARLY states that homework/ content help is not always provided. If you need to learn "How" to do your homework you are required to go look up that complicated information elsewhere on the internet.**

- **The “Foundations” and content of materials to be learned in each math class...are Not going to be supplied by MVP literature.**

basal adjective

**bas·al | \ ˈbā-səl , -zəl **
Definition of *basal*

1a: relating to, situated at, or forming the base

2: of or relating to the foundation, base, or essence : FUNDAMENTAL

Q: What about pacing and a scope and sequence?
A: *The modules are designed such that tasks within a module build to develop mathematical understanding.* ***The modules are sequenced in order to promote integration of the standards for the first course (Secondary One) of the CCSS Integrated Pathway of courses (see Appendix A for the CCSS mathematics standards).*** **However, teachers need to view the materials as a resource and as such use them as they see fit.** *The intent would be to "usually" use a task a day. The teacher may or may not use a task a day depending on the needs of their students as well as such issues as a block schedule and so forth.*

TRANSLATION:
If a Teacher “...may or may not use a task a day” that leads me to believe that this curriculum was only meant to serve as a supplemental experience for students. To be used only to enhance a “current” existing math content curriculum.

MVP is the supplemental material.

Q: Where are the examples?
A: ***The MVP team has authored the materials such that they provide learning through a task-based classroom environment.*** *Students will work collaboratively to develop, solidify and practice important mathematics. Again it is essential for teachers to have an understanding of the intended pedagogy that may best support the implementation of the tasks in the curriculum. In addition to the in-class experience facilitated by the teacher there are Helps, Hints and Explanations that contain examples and explanations as well as help videos available on rsgsupport.org.*

TRANSLATION:
Although, it does not say this...the “Helps, Hints and Explanations” are not included in the MVP program. Students would have to purchase a $40 workbook from MVP to obtain any visual content. You are not able to see what information will be included in these workbooks before ordering. The company MVP does not have a phone number where any employee can be reached for questions.

Q: Where are the lengthy problem sets?
A: *Problem sets are meant to support the learning and thinking that takes place during and after classroom instruction. The **"Ready, Set, Go"** practice sets are intended to support the learning as described. **There are many other resources that have practice sets if a teacher wishes to provide more of this for their students.***

TRANSLATION:
You may or may not have access to math practice problems depending on the discretion of your teacher. Teachers are solely responsible for translating the MVP Literature and manufacturing their "own" practice problems for students.